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ABSTRACT

This teacher's guide focuses on the value and functions of wetlands by integrating science and the politics of wetlands into a geographic framework. Wetlands are highly dynamic, diverse, and prolific ecosystems. The volume advocates a need for mutual understanding and harmony of effort in order to deal with the complex issues of the wetlands. The chapters include the following: (1) "Introduction" expressing a need for mutual understanding and harmony of effort; (2) "Definitions and Geographic Relationships of Wetlands"; (3) "Wetland Systems: Functions, Values, and Delineation"; (4) "Learning Activities K-6, 7-9, 8-10, and Senior High-College." Appendices include: (1) "Glossary"; (2) "Common Wetland Indicator Vegetation"; (3) "How to Use Munsell Soil Indicator Charts"; (4) "Technical Criteria: Hydrophytic Vegetation, Hydric Soils, and Hydrology"; and (5) "Data Form for Delineating Wetlands." Extensive maps, charts, and figures accompany the text. Contains a selected resource list and 30 references. (EH)

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Wetlands: Science, Politics, and Geographical Relationships

John E. Benhart and Alex Margin

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Wetlands: Science, Politics, and Geographical Relationships

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INTRODUCTION

Much has been written about wetlands in recent years. So much, in fact, that the volume and variety of information can overwhelm educators, students, and others interested in wetlands research and study. Many reasons account for the current popularity of the subject; however, most of the recent writings display a new and emerging public awareness about the value and functions of wetlands. They reflect the controversies arising from differing perspectives, attitudes, and interests in wetland areas. As a result, wetland literature tends to emphasize either *scientific* aspects or *political* aspects, but rarely both. The authors will attempt to integrate the science and the politics of wetlands into a geographic framework.

Consider some of the basic geographic questions about wetlands: Where are wetlands located? Why are wetlands located where they are? What are the consequences of altering wetland locations? Human migration and population pressure on the land have imposed serious stresses on wetland resources, making the study of wetlands a newly-emerging geographic concern.

Wetlands are highly dynamic, diverse, and prolific *ecosystems*. They evolve from a multitude of physical and biological processes interacting over vast periods of time with varying degrees of human modification and change. To understand the *scientific aspects of wetlands*, one must first gain a fundamental knowledge of these processes. Individuals must examine the consequences of these physical, biological, and human processes to understand the various wetland types and how one defines, identifies, classifies, and delineates them.

In recent times, the *politics of wetlands* have been no less dynamic than the *biologically diverse wetlands* themselves. At all levels of government, controversies continue over wetlands. Recent court precedents, frequent modifications to regulations and laws, and other politically-based actions often make wetlands writings somewhat dated even before they are published. Keeping abreast of changes and recognizing the political controversy that envelops them become essential and integral parts of wetland issues and studies.

A Need for Mutual Understanding and Harmony of Effort

Rachel Carson, in her 1962 environmental epic, *Silent Spring*, warned: "The rapidity of change and the speed with which new situations are created follow the impetuous and heedless pace of man rather than the deliberate pace of nature." Carson was referring to human interaction within the entire environment, but her words epitomize the historic attitude toward and destructive human intervention of wetlands.

Numerous controversies have arisen among various environmental factions over recent decades. Wetlands now appear to be the newest controversial environmental subject. Differing ideals, attitudes, interests, knowledge, and ethics give rise to conflicting viewpoints. The so-called environmental revolution recognized these and other responsible factors. At the Fourth Annual Conference in Philosophy (Blackstone 1971), ecologist Eugene Odum stated:

> Proper planning and management of environmental resources will require a revolution in the attitudes of human beings, one in which it is recognized that continued population growth, technology, and pollution can place such demands on the earth's finite resources that a quality human existence, if not human existence itself, is rendered impossible.

According to Odum, the foundation for the needed "attitude revolution" must be the development of an *environmental ethic* for and by society at large.

Odum's call for an attitude revolution is proceeding painfully slow. Far too many individuals remain environmentally apathetic. Even more damaging are those who operate at opposite ends of the environmental-awareness spectrum. Anti-environmentalists, on one end, disregard and even show contempt for scientific findings that reveal damage to the environment and to society. At the other end, a growing number of radical environmentalists unwittingly do more harm than good to the overall environmental movement by making quasi-scientific, alarmist claims that discredit legitimate environmental efforts. Such claims mislead the general public and further motivate the anti-environmentalist's stance.

Society must operate with a sound environmental ethic for the greater good. *Environmental unity* means that all elements and processes of the environment are interrelated and interdependent and that any change in one system will lead to a change in another. Environmental unity is the key consideration. True environmental unity is unattainable without a unity of effort by all of society.

Our Changing Attitude about Wetlands

Wetlands, or *wet lands*, of many different types exist throughout the world. We know them by various names, including *bog, fen, marsh, mire,* and *swamp*. Throughout and perhaps even prior to recorded history, people depicted or perceived certain wetland types (particularly swamps) as dark, forbidding places of mystery and omnipresent danger.

Prehistoric humans quite possibly experienced dangers of many kinds in wetlands. To them, the wetland was an alien environment, uninhabitable, and teeming with various threatening life forms. Its mysterious setting posed both real and perceived dangers to individual survival. Wetlands were places to fear, places where roaming animals gathered to hunt other animals in search of drink, where bizarre amphibious and reptilian creatures maintained permanent lairs. We need not speculate about prehistory to consider the real and perceived negative attitudes and realities of wetlands. We need look only to eighteenth century Colonial America to the present.

Throughout history, humans have attempted to subdue nature. The earliest colonizers and developers of the American continent considered wetlands to be little more than insect-infested wastelands, regions of no practical use or value, and responsible for considerable human discomfort. After biologists and medical scientists revealed that insects transmitted diseases such as malaria and yellow fever, wetlands seemed doomed to human intervention and change.

A classic example of the human attitude toward, and intervening on, wetlands occurred during the colonization of North America (Mitsch and Gosselink 1986). Colonel William Byrd III (1674-1744), while surveying the Virginia-North Carolina border, encountered an expansive wetland of about 770 square miles (1994.3 sq km), and named it The Great Dismal Swamp. Byrd thought little of this region, describing it in his surveying log as " [a] horrible desert, the foul damps ascend without ceasing, corrupt the air and render it unfit for respiration... . Never was Rum, that cordial of Life, found more necessary than in this Dirty Place." Two decades later George Washington became a co-owner of a company that attempted unsuccessfully to drain 40,000 acres (17,007.7 ha) of The Great Dismal Swamp for its timber and for future agricultural use of the land.

Eventually, the United States government took an active role in eliminating wetlands to promote agricultural development. Such efforts began with the legislation of the Swamp Lands Acts of 1849, giving Louisiana all "swamp and overflow lands unsuited for agriculture" in order to promote flood-control measures within the lower Mississippi River Valley. The act was amended in 1850 to include twelve additional states northward in the Mississippi River Valley and in the Pacific Northwest. Another amendment in 1860 included the states of Minnesota and Oregon.

During the United States Civil War (1861-1865) tens of thousands of casualties and fatalities resulted, not from the bullet, but through disease. Among the war campaigns with the highest incidence of disease was the six-month Union advance in 1863 led by Ulysses S. Grant southward through the Mississippi River Valley from Memphis, Tennessee to Vicksburg, Mississippi. During the campaign, one of Grant's soldiers commented, "Go any day down the levee and you could see a squad or two of soldiers burying a companion, until the levee was nearly full of graves and the hospitals still full of sick (Foote 1986)." Pneumonia, smallpox, malaria, and yellow fever had taken their toll. Although medical science had not yet discovered direct cause-effect relationships between pathogens and disease, or the transmission of certain diseases by insects, people made associations about where certain diseases were acquired. This fueled efforts to eradicate wetlands.

The United States government continued its wetland eradication policies well into the twentieth century. By then, advances in medicine had greatly reduced the once-legitimate concern about wetland-borne diseases. Agricultural expansion, encouraged and financed by the federal government, hastened wetland destruction. Federal wetlands were handed over to state governments at alarming rates. Of the estimated 221 million acres (81 million ha) of original freshwater and coastal wetlands within the 48 contiguous states, 117.7 million acres (47.7 million ha) or 53 percent had been destroyed during our nation's first 200 years.

The age-old adage "Things are not always as they appear," befits the wetland perspective change that began to surge in the mid-1970s. We can credit the new perspective largely to a few pioneer scientists who performed botanical studies within peat lands and other wetland types during the first half of the twentieth century, leading to the creation of an entirely new science, often termed *wetland science* or *wetland ecology*. Wetland science is a multi-disciplinary effort involving botanists, chemists, earth scientists, ecologists, engineers, geographers, hydrologists, and soil scientists, to name a few. It is a complex study of the integrated natural processes of a landscape that has become neither terrestrial nor aquatic. Wetlands can range from a *tidal* salt marsh that adjoins the deepwater aquatic *habitat* of the Chesapeake Bay or a raised bog in Finland that depends solely upon precipitation for its water supply.

The general public is becoming increasingly aware that wetlands are uniquely important ecosystems, serving many vital roles essential to the natural environment. Wetlands have developed for reason and purpose. Wetlands possess qualities and perform functions that have ecological value to our global environment and economic value to humans.

Wetlands Policies Change Dramatically

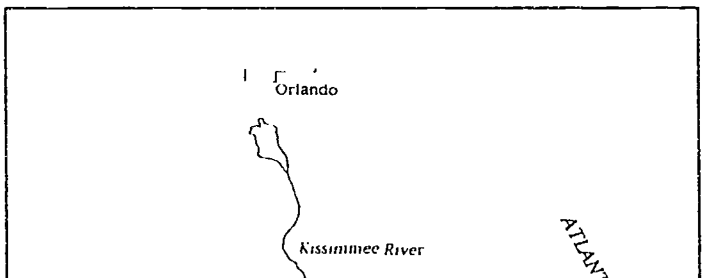
In the past 100 years, the U.S. government wetland policy has changed dramatically. Where our government encouraged and financed habitat destruction, the law now protects and preserves wetlands. Wetlands in the United States, however, continue to be lost at an annual rate approaching 300,000 acres (121,500 ha). Much of this continuing loss of our wetland habitat can be attributed to human endeavors that rely more on personal gain than on societal good. The losses are occurring because of apathy toward wetlands and wetland regulations, accidental actions by human activities within close proximity to sensitive wetland areas, ignorance of the natural roles performed by wetlands and of the regulations that now protect them, and inadequacies within the current regulations.

We have made great strides in our knowledge of and attitude toward wetlands. Much needs to be accomplished. "[As] long as wetlands remain more difficult to stroll through than a forest or more difficult to cross by boat than a lake, they will remain a misunderstood ecosystem to many people (Mitsch and Gosselink 1986)." We can and must minimize misunderstanding within the general public. Education is the key. The challenge is to increase awareness among the general public and to promote continuing research among the wetland professionals. A true understanding of wetlands involves a knowledge of many complex disciplines. Wetlands encompass far more than the rudimentary fields of botany, hydrology, and soil science. Wetlands are *spatial* phenomena, a matter of concern to the discipline of geography. We must, therefore, perceive and manage wetlands *holistically*, within the context of the fundamental themes of geography: *location, place, human-environmental interaction, movement,* and *regions.*

The Everglades

The Kissimmee River originates in central Florida south, southwest of the city of Orlando (fig. 1). Two years prior to its channelization in 1961 by the Army Corps of Engineers, it slowly meandered southward to function as the primary feeder of Lake Okeechobee. After channelization, however, the original 103 mile (165.7 km) length was shortened into a 56 mile (90.1 km) canal that in turn destroyed 30 thousand acres (12,150 ha) of wetlands. Lake Okeechobee discharges excess water into the flat, porous, limestone bedrock terrain of southern Florida. The coast of southern and southwestern Florida does not end at the shore line, but extends far out into the Gulf to form the Ten Thousand Islands. This entire region, with defined hydrologic inputs and outputs, along with the types of natural vegetation indigenous to the area, may be defined as an emergent and scrub/shrub swamp.

Figure 1: Southern Florida and the Everglades



The Everglades National Park, established in 1947, is composed of 1.5 million acres (607,500 ha) along the southern tip of Florida (fig. 2). This includes the Florida Bay and the Thousand Islands along the southwestern coast. It is the largest national park in the continental United States. In addition, the creation of Big Cypress National Preserve during the 1970s and a number of other water conservation areas comprise the majority of protected areas within the greater Everglades hydrologic region.

Although these wetlands are highly sensitive to human activity, little has been done to protect the health, biodiversity, water quality and quantity of the Everglades region until the last few years. With the explosive growth of the surrounding areas, especially during the last few decades, efforts have been launched to reclaim portions of the Everglades outside of the park.

Figure 2: The Everglades have sensitive and fragile wetland ecosystems that are critical to the future environmental quality of Florida.

Agriculture directly affects the quality and quantity of water flowing into the Everglades. Sugar cane farming, the primary agriculture of the surrounding area, covers 500,000 acres (202,500 ha) south of Lake Okeechobee. An additional 50,000 acres (20,250 ha) of vegetable farms are located in the region. Nutrient loading, irrigation, and eutrophication affect the wetlands of the Everglades.

Land use pressures affect the Everglades in a number of ways. The development of urban areas, especially along the southwest shoreline of the Florida peninsula in large metropolitan areas such as Fort Lauderdale and Miami, has increased the need for water. Approximately 4 million people depend on water diversion from the Everglades to satisfy their needs. Encroachment into wetland areas by urban sprawl has resulted in the loss of around half the original Everglades expanse. Planned is a one billion dollar recreation and tourist site in a water conservation area bordering the north of the Everglades National Park. Construction for the blockbuster park covering 2,500 acres (1,012.5 ha) is scheduled for 1995. It would take up to 10 years to complete and an estimated 7 million people would visit each year after completion. The development of the park would seriously affect water quantity and quality of the Everglades ecosystem.

Since 1983 with the creation of "Save Our Everglades" led by the Environmental Coalition, a collection of community leaders began to realize the Kissimmee River has direct effects on the environmental health of the entire Everglades region. Starting in the summer of 1994, 26 miles (41.8 km) of the Kissimmee River will be filled back in, which will ultimately restore 40 square miles (103.6 sq km) of river and floodplain ecosystems (In the past, the river channel lost more than 35 miles (56.32 km) as a result of channelization). Of the 30,000 acres (12,150 ha) of wetlands lost during river channelization, 26,500 acres (10,732.5 ha) are expected to be restored.

The end result will be the restoration to Kissimmee River pre-channelization standards, i.e., to the original flow volume and stream course, along with the riverine wetlands ecosystem.

The state of Florida passed a second action in May of 1994 that addressed many of the problems south of Lake Okeechobee. Its major emphasis is to construct 40,000 acres (16,200 ha) of artificial impoundments filled with hydrophytic vegetation. Pumps will draw polluted water from some of the existing 1,400 miles (2,256 km) of channels into the artificial marshes. Water moving through the marshlands, will filter out pollutants and pumps will draw out the resulting clean water and discharge it into the Everglades.

2

DEFINITIONS AND GEOGRAPHIC RELATIONSHIPS

The U.S. Fish and Wildlife Service provided one of the earliest official definitions of a wetland (Shaw and Freud 1956, 3):

> The term "wetlands" ... refers to lowlands covered with shallow and sometimes temporary or intermittent water. [Wetlands] are referred to by such names as marshes, swamps, bogs, wet meadows, potholes, sloughs, and river overflow lands. Shallow lakes and ponds, usually with emergent vegetation as a conspicuous feature, are included in the definition, but the permanent waters of streams, reservoirs, and deep lakes are not included. Neither are water areas that are so temporary as to have little or no effect on the development of moist-soil vegetation.

A newer U.S. Fish and Wildlife Service definition has superseded the 1956 definition and provides a common basis for all subsequent definitions. The definition recognized three fundamental characteristics shared by all wetland ecosystems: (1) hydrology, (2) hydric soils, and (3) hydrophytes, or hydrophytic vegetation. These are defined as:

1. *Hydrology* - The presence of water at or near the surface at some time during the *growing season*, excluding true aquatic areas, i.e., areas permanently flooded at a depth greater than 6.6 feet (2.01 m). Not simply the presence of water, but remnant signs of the past presence of water are also important indicators of wetland hydrology. Examples include:

   a. receded floodwaters often leave tree litter (such as leaves, twigs) accumulation against tree trunks and other vegetation;

   b. trees often produce swollen tree trunks, or *buttresses*, when they grow in flooded conditions (the bald cypress is a familiar example).

2. *Hydric soils* that are *saturated, flooded,* or *ponded* long enough during the growing season to develop oxygen-deficient conditions near the soil's surface, specifically within the root zone of plants.

3. *Hydrophyte plant species* that require or are tolerant of saturated soil conditions. (See Appendix A).

Despite recognition of these common factors, no consensus remains on a single definition because:

- Wetlands vary greatly in type. A single definition must take into account the differences between, e.g., a marine salt marsh and a riverine bottomland hardwood forest.
- Wetlands are highly complex in their physical, chemical and biological makeup. Using the same example, many of the physical differences between a marine salt marsh and a riverine bottomland hardwood forest are readily obvious.

The major chemical difference between types of wetlands is the *salinity* of the water. Many other chemical differences exist between the hydric soils of salt marsh and the bottomland hardwood. With these differing physical and chemical attributes come differences in the biological makeup of the wetland.

- The diversity and complexity of wetlands are so great that a single, scientific definition may not be possible. Different climates have evolved unique wetland types. Wetlands are distributed on every continent except Antarctica, where the polar climate prohibits wetland evolution. Wetlands exist in all types of topography, from coastal regions to mountainous areas. Wetlands are found on urban, rural, and pristine landscapes. The size of a wetland can range from less than 1 acre (0.405 ha) to thousands of square miles (or sq km).
- *Legal definitions* of wetlands are based mostly on scientific evidence but often with political considerations. Several U.S. federal definitions are currently in use and many states have adopted definitions from these federal definitions. Innumerable legal conflicts between nature conservationists and proponents of land-use development have ensued because of various political or legal actions.

Other complicating factors about a wetland definition, and about wetlands in general, include:

- The term wetland has been misleading to the layperson because many wetlands are visibly *wet* for only a small portion of the year.
- Reference or inventory maps are far from complete for the contiguous 48 states despite ongoing efforts to inventory wetland locations. Among the states, only Hawaii's wetlands have been thoroughly inventoried. Little inventory work has begun in most other areas of the world. Only gross estimates have been made in these locations. For example, total wetland area estimation for Alaska varies from 130 million to 300 million acres (52.7 million to 121.5 million ha). The global wetland coverage is estimated to be 6 percent of the earth's land surface, of which only a tiny fraction has been mapped accurately.
- Human influence has complicated the scientific analysis of some wetland landscapes. Such influence may be as intentional as draining and filling a wetland for agricultural use; unintentional alteration of wetland waters and soils by way of *point-source* or *non-point-source* chemical contamination from a factory. Adverse human influence may be direct or indirect and intentional or unintentional.
- Human-designed wetlands may or may not have the same biological and chemical characteristics of a natural wetland. It is possible to mimic the diverse appearance of the physical characteristics of natural wetlands in an *artificial wetland*. It is not possible to replicate the

chemical composition of the substrate because the *soil* of an artificial wetland will not be hydric unless the artificial wetland construction takes place where a natural wetland once existed. In this sense, artificial wetlands are superficial at best; they can, however, serve useful purposes when engineered properly.

Introduced species of plants and animals are common additions to artificial wetlands. In the past and even now, little or no knowledge, thought, or concern is evident to matching indigenous species to a particular locale, or what effects non-native species may have on the ecosystem. The common carp (*Cyprinus carpio*), a prolific fish introduced into the United States during the late 1880s by the U.S. Fish Commission as a food fish, has become a detriment to native fish populations. Yet it has never gained popularity as a game or food fish as those who introduced it intended. Among the introduced plant species, most have been added to the landscape for ornamental reasons or as an aid to control erosion. Indiscriminate introduction of the carp and other animal and plant species have had and can have serious effects on the native flora and on the ecosystem. Species introduction is not merely a potential concern of artificial wetlands. Humans have intentionally and unintentionally altered the flora and fauna of many natural wetlands.

- A comprehensive federal wetland policy is nonexistent. The current regulations regarding land use and water quality are the responsibilities of numerous and varied federal, state, and local agencies. Until the land use and water quality regulations are combined into one, comprehensive regulation under the purview of a single agency, federal wetland management will meet with difficulties. Under the current management scheme, one contributing factor to wetland management failure has been a serious lack of expert personnel in land use and water quality disciplines working in a united effort.
- Jurisdiction over wetlands is the responsibility of both the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers. The past history of administrative guidance and interagency coordination between these agencies has been poor.

One notable exception to the history of failed interagency coordination occurred in January 1989, when the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* was formally adopted. The manual is the result of a cooperative effort among the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, and the U.S. Department of Agriculture Soil Conservation Service. The dilemma of a single, all-encompassing wetland definition remains, as the manual contains each of the following three definitions:

1. The contemporary U.S. Fish and Wildlife Service (FWS) definition (post-Circular 39) was originally cited within a report, *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al. 1979, 3). It states:

> Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water... . Wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.

2. Another definition, used by the U.S. Army Corps of Engineers (CE) and the Environmental Protection Agency (EPA) for administering Section 404 of the Clean Water Act (EPA, 40 CFR 230.3 1992, 200 and CE, 33 CFR 328.3 1992, 484) states:

   The term 'wetlands' means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that und : normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

3. A third definition, used by the U.S. Soil Conservation Service (SCS) for determining farmer eligibility under the provisions of the 1988 National Food Security Act, is also cited within the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands*:

   Wetlands are defined as areas that have a predominance of hydric soils and that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions, except lands in Alaska identified as having a high potential for agricultural development and a predominance of permafrost soils.

Key differences within the above definitions are the exemption of Alaska within the SCS definition and the inclusion of both vegetated and nonvegetated areas (*mud flats, rocky shores, sand bars*, etc.) within the FWS definition. Although each of these official wetland definitions recognizes hydrology, hydrophytic vegetation, and hydric soils as fundamental elements of a wetland, differences are sufficient to generate continued controversy in wetland conservation versus land use development efforts. The multi-agency wetland identification and *delineation* manual, composed by a collective group of the most notable experts within the subdisciplines of wetland science, is possibly a first step toward a comprehensive federal wetland policy. The absence of a single, comprehensive wetland definition within the manual, however, epitomizes the complexity of wetland science and its politics.

Geographic Relationships of Wetlands

Geography is essential for assisting humans to understand the complexities of physical and cultural characteristics that influence the modern world. Geography helps us to manage fragile environmental resources such as wetlands upon which we depend for environmental health and vitality. Sophisticated environmental decision making and changing technologies make geographic knowledge a crucial component in future wetland analysis.

Studying the geography of wetlands must start with ascertaining the location of wetlands on a portion of Earth's surface (figs. 3 and 4). Geographic knowledge helps to explain why wetlands are located where they are and what consequences their distributional patterns have on the population. To assist in understanding the geographic relationships of wetlands, we can use the *fundamental themes in geography*: (1) *location*, (2) *place*, (3) *human-environmental interactions*, (4) *movement*, and (5) *regions* to organize our thinking about these phenomena.

Location: We can pinpoint *location* of wetlands on Earth by using an imaginary grid of lines that denote *latitude* and *longitude*.

Relative location is how a place is related to other places by cardinal direction, proximity, distance, or well-known places nearby. Locational characteristics are crucial in understanding local, regional, and global interdependence.

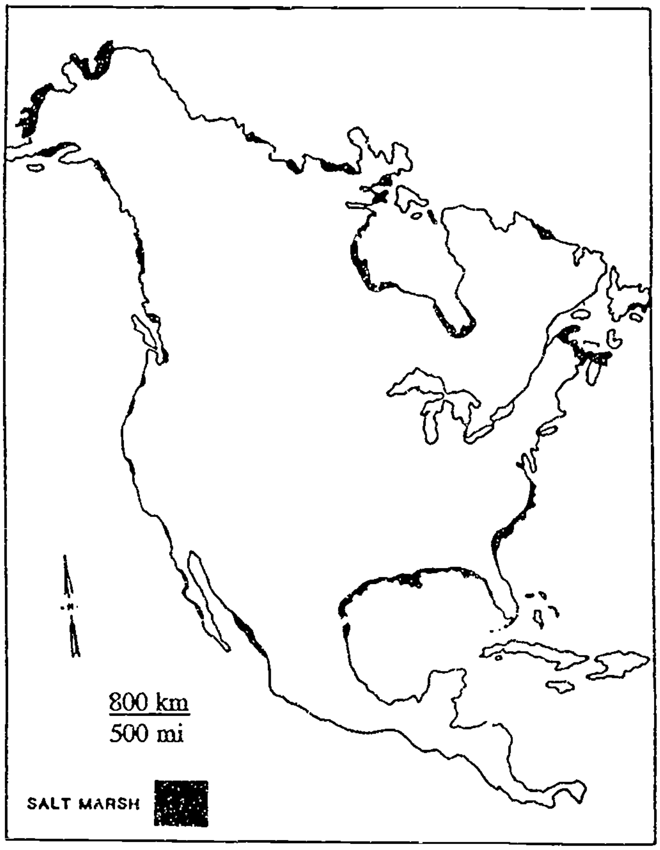


Figure 3: Geographic Distribution of Salt Marshes in North America (Adapted from Mitsch and Gosselink 1986, 175).

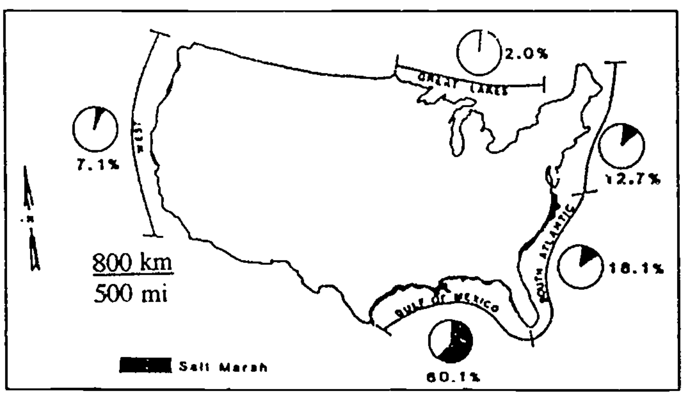


Figure 4: Percent distribution of coastal marshes in the contiguous United States by region (Adapted from Gosselink and Baumann 1980, 180).

Water can enhance the interaction between and among places as part of relative location. For example, Where are wetlands located, and why? Do the locations indicate population growth or decline? What are the advantages and limitations of wetlands in the region?

Place: All places have unique geographic *criteria* that identify them as distinctive areas on Earth's surface. Geographers characterize places by their particular physical and cultural aspects.

Do the wetlands have any vegetation, wildlife, soil, or climatic characteristics that distinguish them from other places? How will future transportation facilities influence wetland locations or vice versa? What unique natural features encourage the preservation of wetlands in the area? Is there evidence of urbanization nearby? Is population density a factor in the preservation of wetlands in the region? What areas in the region are periodically saturated or covered by water? What types of plant and animal species are associated with various types of wetlands?

Human-Environmental Interactions: Geographers study the effects that occur when humans interact with the physical environment. Each place on Earth's surface has unique characteristics that makes it suitable or unsuitable for various types of settlement patterns. Geography focuses on understanding how cultural values, economic systems, political circumstances, and technology influence the environment.

What are the population distribution patterns in and around wetlands? Which areas have the greatest population density? Least? Is evidence of human modification of wetlands apparent? How are wetlands being used? Are land use developments planned that will disturb wetland habitats? What are the natural and human benefits of wetland preservation? What is the significance of wetlands to recreation and wildlife resources? Of what value are wetlands? How do wetlands benefit the people of the region? How do wetlands enhance environmental health and sanitation in the area?

Movement: Human occupation on Earth includes people living in cities, on farms and in other urban, suburban, and rural locations. People interact with each other daily by automobile, bus, train, airplane, various electronic media, and face-to-face exchange of ideas, information, and products. Planning for city water supply, storm water management, and floodplain preservation influences the future quality of wetlands. Wetland preservation has a strong relationship with the movement of water, fish, and wildlife. Water resource conservation enhances life forms throughout various ecosystems.

What are the products of wetlands? How does the movement of water through wetlands influence water quality? How do wetlands influence the migration of fish and wildlife? What are the barriers to preserving wetlands? Are they human or natural barriers?

Region: A region is an area of the earth's surface defined by specific criteria that distinguish it from another region. Physical or cultural factors may be the unifying factors that distinguish a region.

Geographers can *delimit* wetland regions for specific purposes of preservation, recreation, or improved environmental quality.

What is a wetland region? Can you describe or define a particular wetland region? Are any visible boundaries of wetlands apparent? Why are wetlands present in a particular area? How do boundaries vary in different types of wetlands? What evidence is available of governmental intervention in wetland development and change? How might a wetland be described for its uniqueness? Why are wetland locations important for the environmental quality of the region in which they are located?

Distinctive locational characteristics of inland freshwater marshes, for example, are found in greatest abundance among the once-glaciated regions west of the Great Lakes in Wisconsin, Minnesota, and the Dakotas (fig. 5). Abundant glacial meltwater, glacially-influenced topography, and warm summer climates combine to make the region rich in wetland ecosystems.

Bottomland hardwood forests are found primarily in the southeastern United States (fig. 6). The bottomland hardwood forest is concentrated in the lower Mississippi River *alluvial* valley as far north as southern Illinois.

Wetlands and Sustainable Development

The best way to balance wetland conservation and economic development is by using the principles of *sustainable development.* The basis of sustainable development is the recognition that a nation cannot reach its economic goals without also achieving social or environmental goals, i.e., universal education and employment opportunities, universal health care, equitable access to and distribution of resources, stable population, and a sustained natural resource base (WRI 1994). Careful use of wetlands, while maintaining their ecological health, can enable countries of the

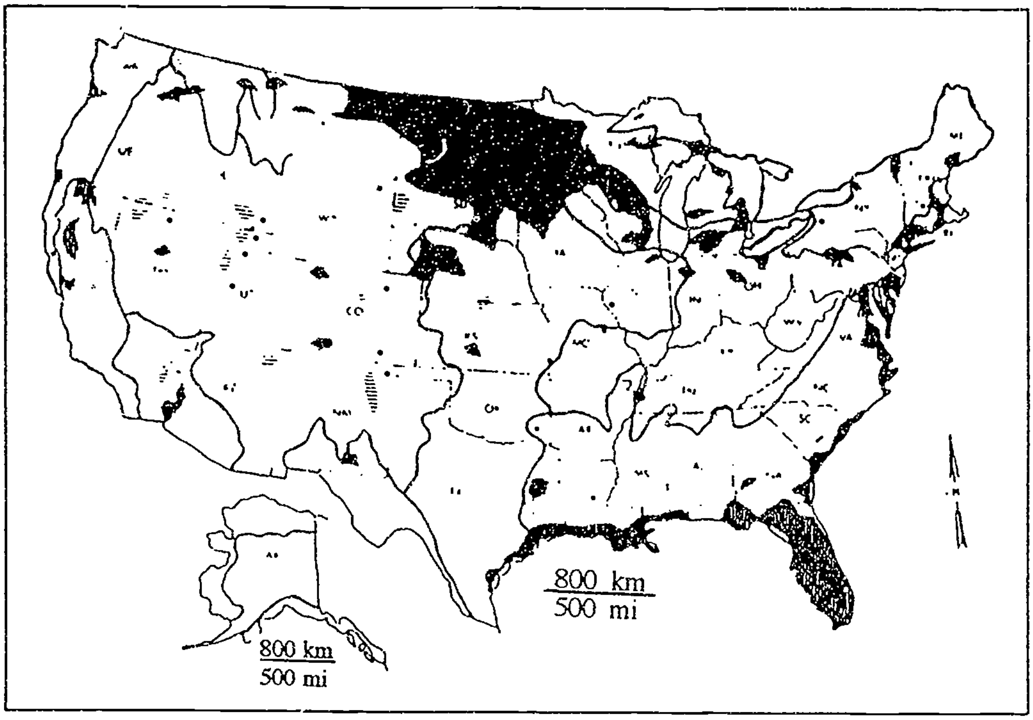


Figure 5: Location of the Major Groups of Inland Freshwater Marshes in the United States (Adapted from Hofstetter, 1983, 213).

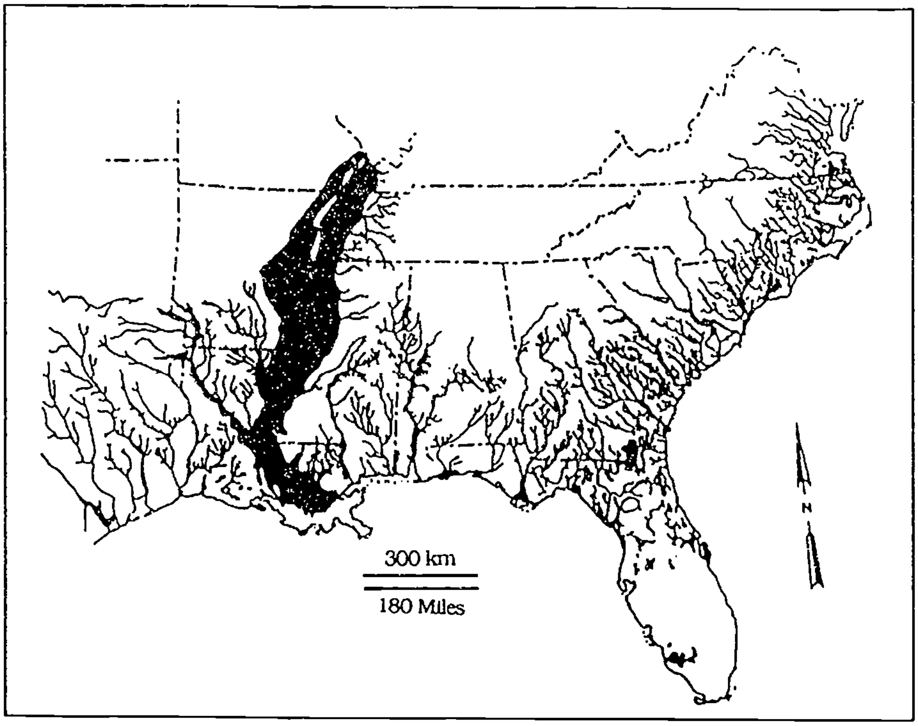


Figure 6: Extent of Bottomland Hardwood Forest of Southeastern United States (Adapted from Mitsch and Gosselink, 1986, 356).

world to engage in wetland conservation and still achieve some of their economic development goals.

Wetlands can serve as low cost, easily maintained facilities for cleaning and filtering wastewater. Treating sewage in the conventional way is expensive. The United States has spent more than 57 billion dollars since 1972 on the construction of sewage treatment plants (WRI 1992). A 1987 study done in Sweden concluded that the benefits of using land for wastewater treatment are greater than the value of the same land if used for agricultural production (WRI 1992). Another study estimates that one acre of tidal wetland can substitute for a 75 thousand dollar (and would have a total land value of 83 thousand dollars when its production for fish for food and recreation is included) waste treatment plant (Miller 1992).

Building new wetlands for wastewater treatment would result in replacing some previously destroyed wetland. The new wetlands would not have the same quality as a natural system, but they would be a great improvement over continuing loss of wetlands. Certain wetland types such as salt marshes and mangrove swamps are difficult to develop. Other types like bogs and bottomland hardwood swamps are harder to create and may not achieve the desired level of functioning (Saluesen 1990).

Arcata, California has converted 156 acres (63.18 ha) of a former garbage dump into a new wetland for use as a wastewater treatment facility. The wetlands remove nutrient wastes, organic wastes, and toxic materials from city wastewater. The city wastewater goes first into oxidation ponds that allow solids to settle and be disintegrated partially. The water then goes into wetlands for additional cleaning. Some of the wetland-treated water is used for irrigation; the rest is pumped into the bay. These new wetlands are attractive and serve as a habitat for waterfowl, otters, and marine animals. The system has saved the city money because the wetlands are cheaper to build and maintain than a wastewater treatment plant. They use more land, but the total benefits far outweigh the costs (Miller 1992).

The Nile River Basin

The Nile River basin includes part of nine countries that depend on the water resources of the basin. After the construction of the High Aswan Dam in the 1960s, the Nile River no longer flooded and deposited alluvium deposits during the annual floods that had occurred in the valley. Flood control destroyed many wetlands but new irrigation programs developed with the construction of the High Aswan Dam greatly expanded agricultural land along the Nile Valley.

The Nile Valley is a good example of environmental unity where a change in one aspect of the environment leads to other changes. The High Aswan Dam provided the steady flow of water along the Nile Valley to provide irrigation during the entire year. The elimination of periodic flooding that deposited silt results in decreasing soil fertility and requires farmers to use increasing amounts of fertilizer to maintain soil fertility. Over-expansion of irrigation puts increased pressure on the technological system of the High Aswan Dam. Population growth along the Nile Valley has increased steadily to the point that more than 98 percent of Egypt's population now lives on 3.5 percent of the land. Sewage and agricultural runoff stimulate algae growth and pollution in the Nile River (fig. 7).

Valuable wetlands have been removed because of the dam's disruption of the normal flooding cycle. In time, an accurate assessment can be made of the relationship of the construction of the High Aswan Dam to sustainable development in the Nile Valley.

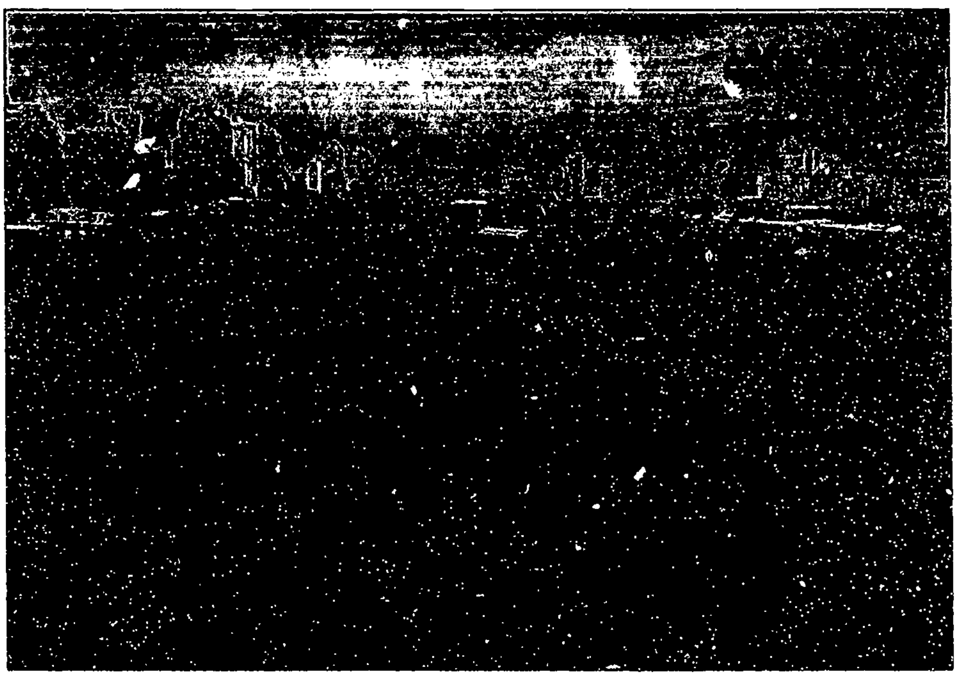


Figure 7: Nile River sewage and agricultural runoff increase the growth of floating algae and adversely affect the river's aquatic life. The population growth along the Nile Valley placed great pressure on water and wetland resources of the region.

3

WETLAND SYSTEMS, FUNCTIONS, VALUES, AND DELINEATION

The hierarchical scheme (fig. 8) is the most extensive classification of naturally occurring wetlands in use to date. "Ecologically related areas of deep water, traditionally not considered wetlands, are included in the classification as deepwater habitats (Cowardin et al. 1979, 1)" because wetland and deepwater ecosystems often occur contiguous to one another. Within the classification scheme are three major hierarchical levels of wetlands and deepwater habitats: System, Subsystem, and Class, followed, in order, by three minor levels: Subclass, Dominance Type, and Modifiers.

A simplified definition of each *System* appears below. Refer to Figures 9 through 13 (adapted from Cowardin et al., 1979) for illustrative examples of each system and its components.

1. **Marine** (oceanic): Open ocean overlying the continental shelf and its associated high-energy coast line.

2. **Estuarine** (tidal): Deepwater tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land but have open, partially obstructed, or sporadic access to the ocean and in which freshwater *runoff* from the land occasionally dilutes ocean water.

3. **Riverine** (river): Wetland and deepwater habitats contained within a channel with two exceptions: (a) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (b) habitats with water containing ocean-derived salts in excess of 0.5 *parts per thousand.*

4. **Lacustrine** (lake): Wetlands and deepwater habitats with all of the following characteristics: (a) situated in a topographic depression or a dammed river channel; (b) lacking trees, shrubs, persistent emergents, emergent mosses, or lichens with greater than 30 percent areal coverage; and (c) total area exceeds 20 acres (8.1 ha). Similar wetland and deepwater habitats totaling less than 20 acres (8.1 ha) are also included in the lacustrine system if an active wave-formed or bedrock shoreline feature makes up all or part of the boundary, or if the depth in the deepest part of the basin exceeds 6.6 feet (2.01 m) at low water.

Figure 8: Classification Hierarchy of Wetlands and Deepwater Habitats (Adapted from Cowardin et al. 1979, 5)

WETLANDS AND DEEPWATER HABITATS

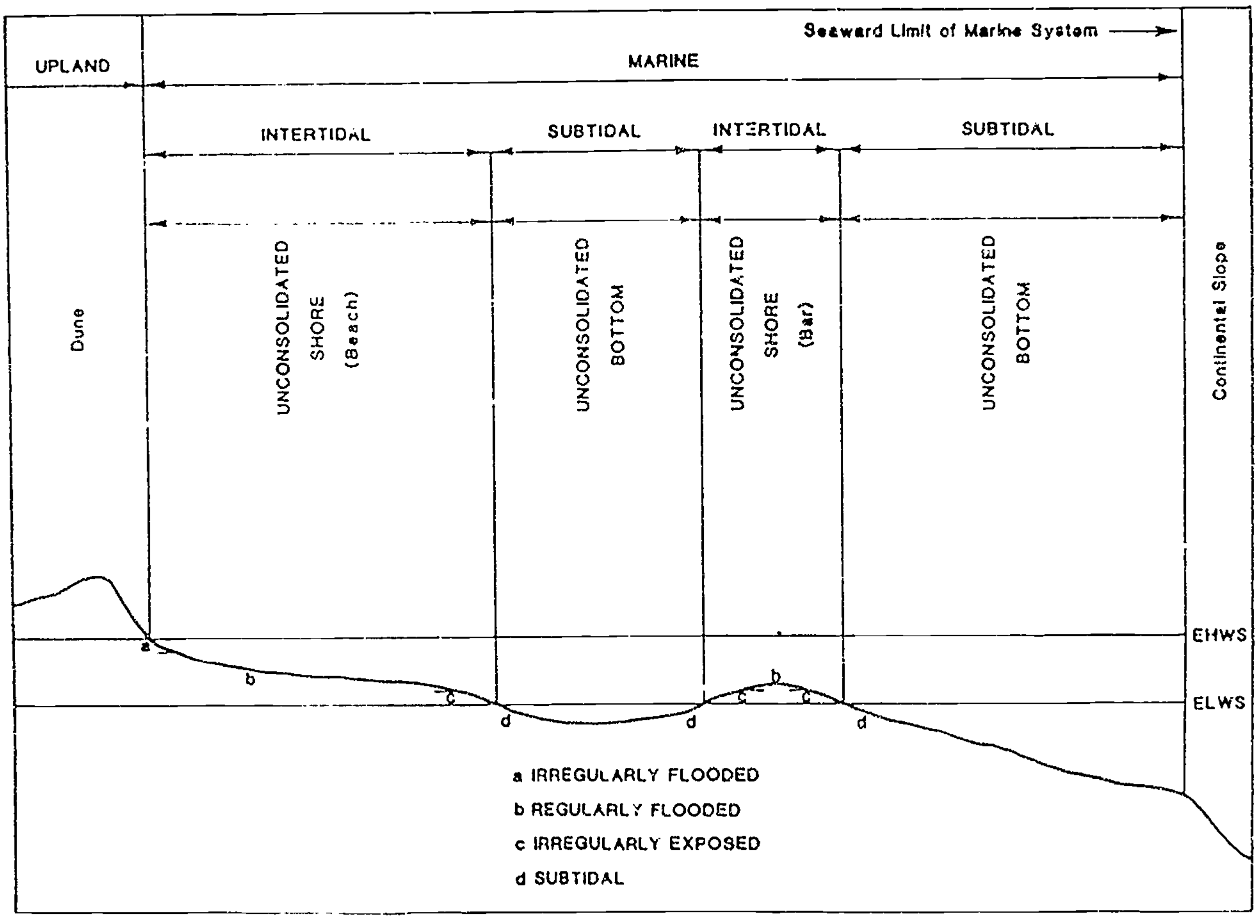
SYSTEM	CLASS	SUBSYSTEM
	Rock Bottom	
	Unconsolidated Bottom	Subtidal
Marine	*Aquatic Bed*	
	Reef	
	Rocky Shore	Intertidal
	Unconsolidated Shore	
	Rock Bottom	
	Unconsolidated Bottom	
	Aquatic Bed	Subtidal
	Reef	
	Aquatic Bed	Estuarine
	Reef	
	Streambed	
	Rocky Shore	
	Unconsolidated Shore	Intertidal
	Emergent Wetland	
	Scrub-Shrub Wetland	
	Forested Wetland	
	Rock Bottom	
	Unconsolidated Bottom	
	Aquatic Bed	Tidal
	Streambed	
	Rocky Shore	
	Unconsolidated Shore	
	Emergent Wetland	
	Rock Bottom	
	Unconsolidated Bottom	

SYSTEM	CLASS	SUBSYSTEM
	Aquatic Bed	
	Rocky Shore	Lower Perennial
	Unconsolidated Shore	
Riverine	*Emergent Wetland*	
	Rock Bottom	
	Unconsolidated Bottom	Upper Perennial
	Aquatic Bed	
	Rocky Shore	
	Unconsolidated Shore	
	Streambed	Intermittent
	Rock Bottom	
	Unconsolidated Bottom	Limnetic
	Aquatic Bed	
Lacustrine	*Rock Bottom*	
	Unconsolidated Bottom	
	Aquatic Bed	Littoral
	Rocky Shore	
	Unconsolidated Shore	
	Emergent Wetland	
	Rock Bottom	
	Unconsolidated Bottom	
	Aquatic Bed	
Unconsol-idated shore	*Moss-Lichen Wetland*	
	Emergent Wetland	
	Scrub-Shrub Wetland	
	Forested Wetland	
Palustrine*		

*The Palustrine System has no deepwater habitats; therefore, no Subsystems exist.

Figure 9: Distinguishing Features and Examples of Habitats in the Marine System (Adapted from Cowardin et al. 1979, 9).

EHWS = extreme high water of spring tides ELWS = extreme low water of spring tides

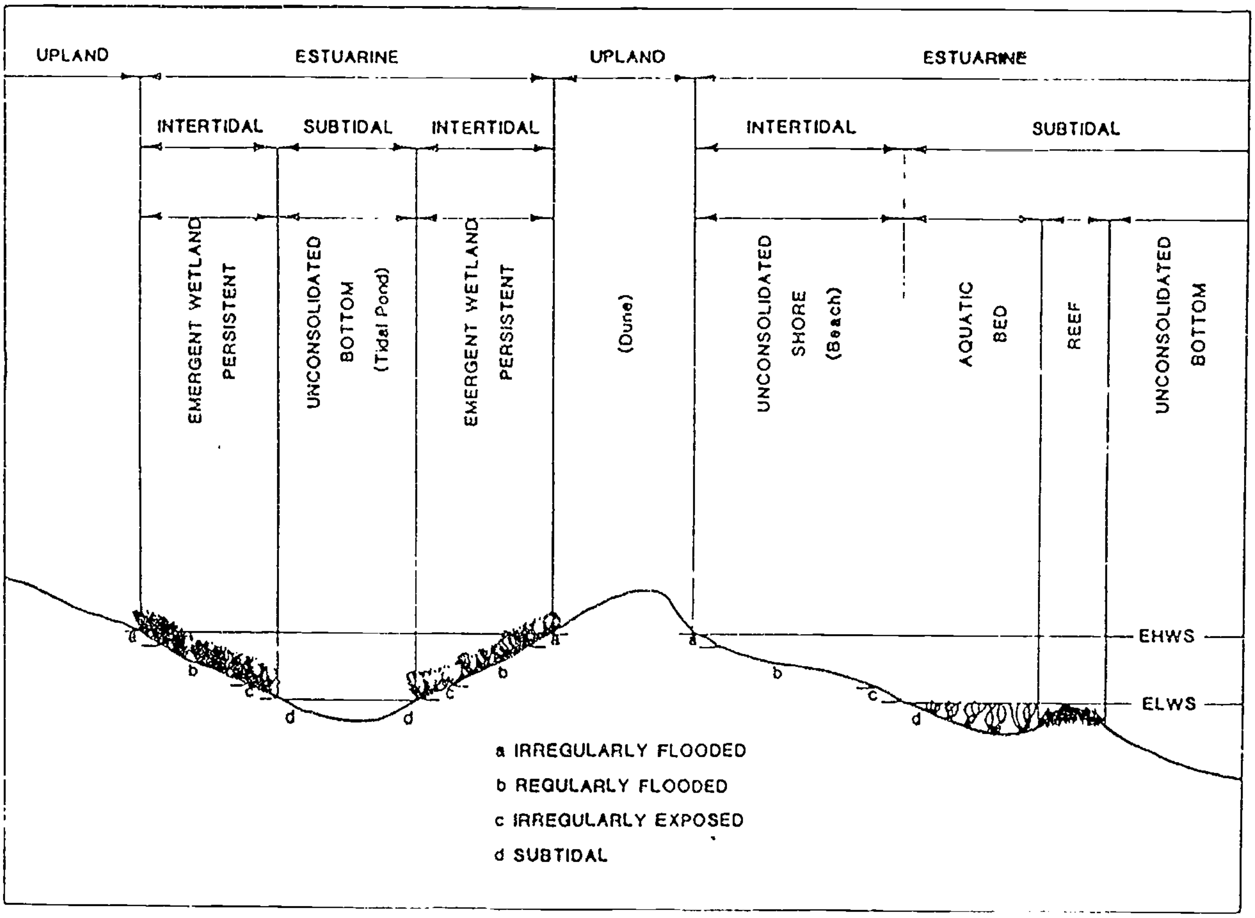


5. *Palustrine* (marsh): All nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity from ocean-derived salts is below 0.5 parts per thousand. It also includes wetlands lacking such vegetation, but with all of the following characteristics: (1) area less than 20 acres (8.1 ha); (2) active wave-formed or bedrock shoreline features lacking; (3) water depth in the deepest part of basin less than 6.6 feet (2.01 m) at low water; (4) salinity from ocean-derived salts less than 0.5 parts per thousand.

The five major systems are further refined (Cowardin et al. 1979, 4-12) by *subsystems*. The subsystems for each major system are:

- Marine and Estuarine Systems
  (a) *Subtidal* - The substrate is continuously submerged.
  (b) *Intertidal* - The substrate is exposed and flooded by tides; includes the splash zone.

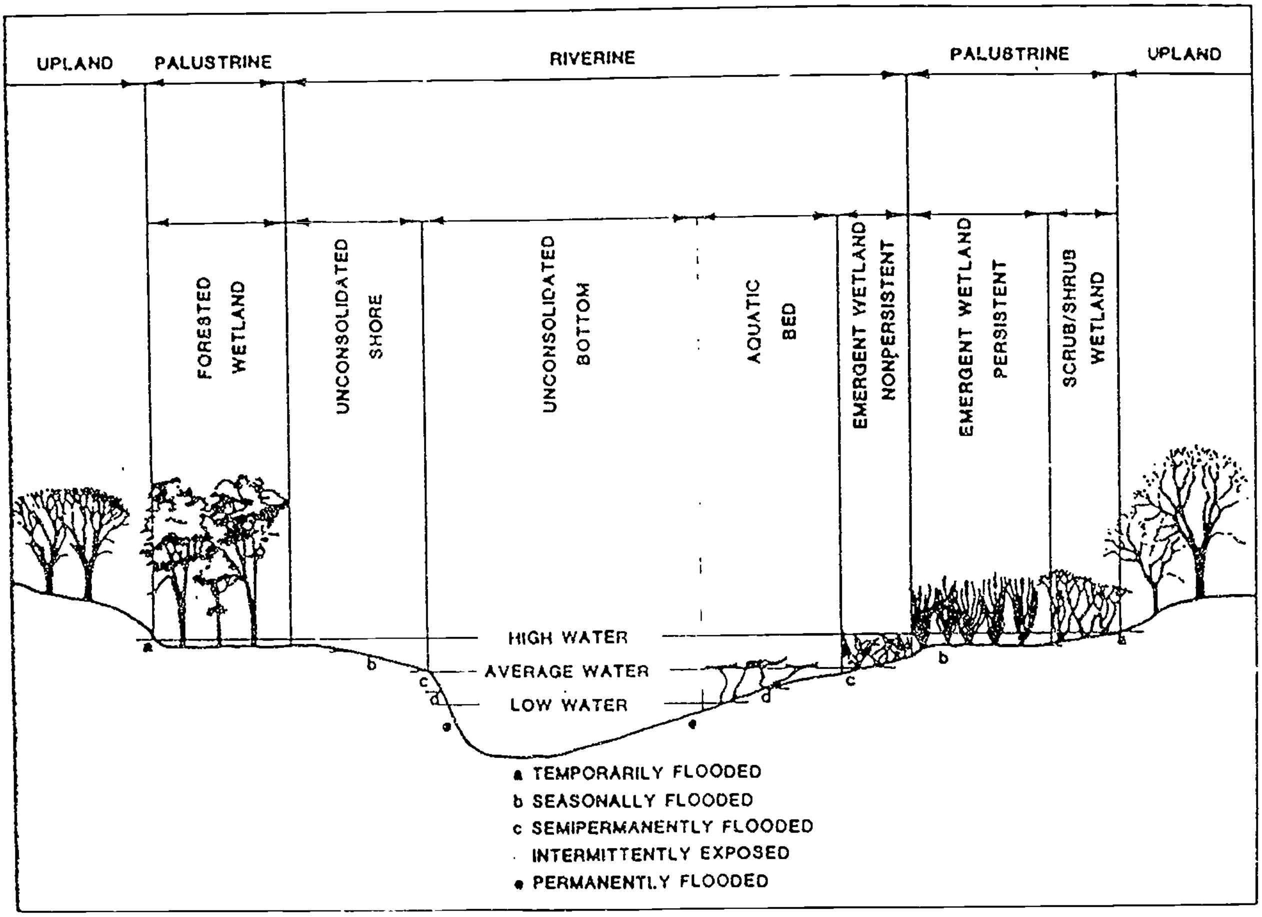
Figure 10: Distinguishing Features and Examples in the Estuarine System (Adapted from Cowardin et al. 1979, 9).



- Riverine System
  - (a) *Tidal* - The *hydrologic gradient* is low and water velocity fluctuates under tidal influence.
  - (b) *Lower Perennial* - The hydrologic gradient is low with continuous flow of water, and no tidal influence occurs.
  - (c) *Upper Perennial* - The hydrologic gradient is high with continuous flow of water, and no tidal influence occurs.
  - (d) *Intermittent* - Water does not flow for part of the year.

- Lacustrine System
  - (a) *Limnetic* - Deepwater habitats (a nonwetland subsystem).
  - (b) *Littoral* - Wetland habitats that extend from the shore to a depth of 6.6 feet (2.01 m) below low water or to a maximum extent of nonpersistent *emergent plants*.

Figure 11: Distinguishing Features and Examples in the Riverine System (Adapted from Cowardin et al. 1979, 11).

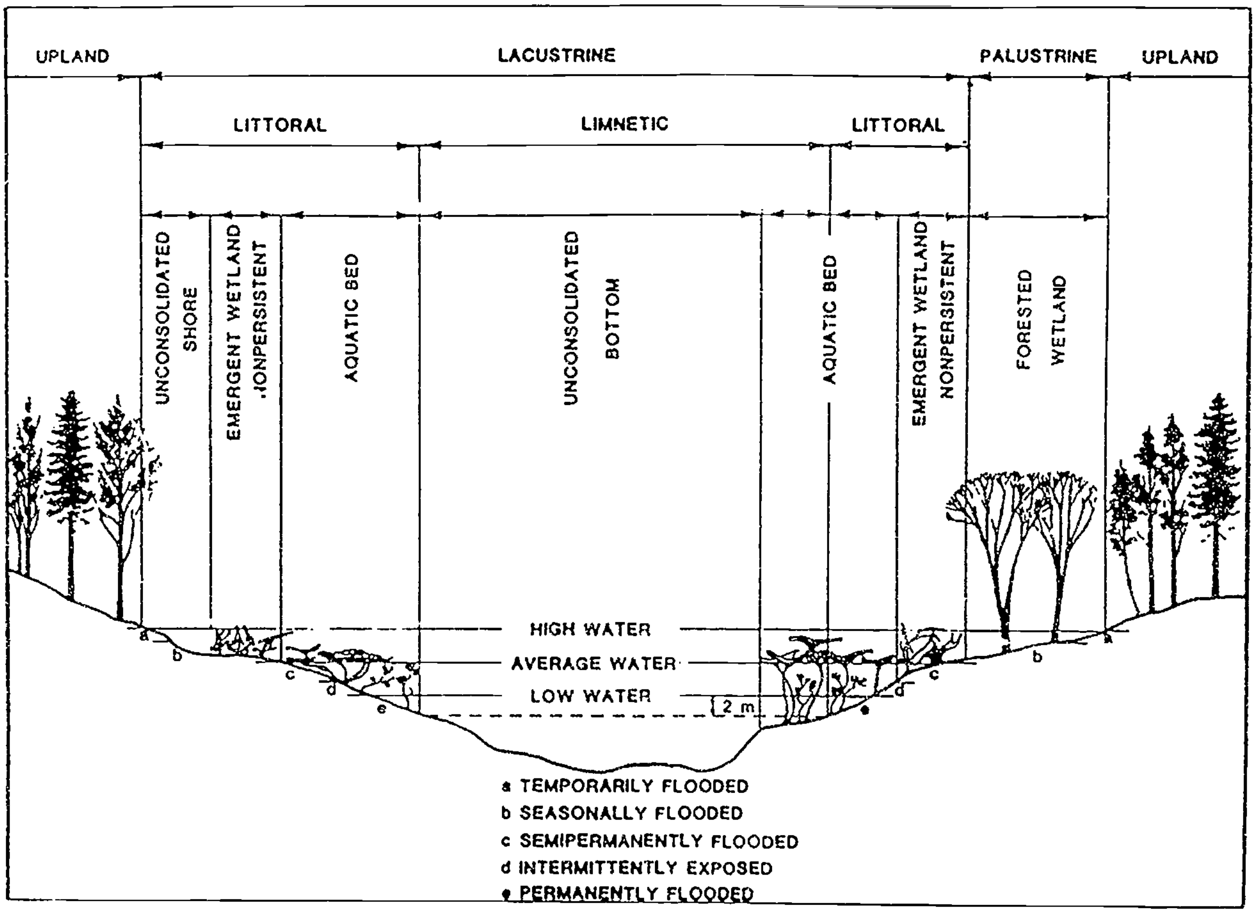


The *Palustrine System* classification excludes subsystems. Palustrine systems (and all of the other subsystems) are further defined by *class*).

Eleven different *classes* are recognized in the classification hierarchy (fig. 8). Classes are groupings of habitats based on readily observable characteristics pertaining either to the dominant vegetation or the physiography and composition of the substrate, hence, the vegetative classes (e.g., *Forested Wetland*) and substrate classes (e.g., *Rock Bottom*). When 30 percent or greater vegetative cover exists, the habitat is defined with a vegetative class. If the area has less than 30 percent vegetative cover, the habitat is defined by a substrate class. The Glossary (Appendix A) provides a condensed definition of each class.

The *Subclass* level of the hierarchical classification (not shown on fig. 8) recognizes finer differences in life forms. "For example, *Forested Wetland* is divided into the Subclasses Broad-leaved Deciduous, Needle-leafed Deciduous, Needle-leafed Evergreen, and Dead (Cowardin et al. 1979, 11)." The terms *persistent* and *nonpersistent* are sometimes used to give further definition to the type of vegetation within a wetland, such as the *Emergent Wetland* (fig. 11).

Figure 12: Distinguishing Features and Examples in the Lacustrine System (Adapted from Cowardin et al. 1979, 12).



- *Dominance Type* refers to the dominant plant and animal species of the habitat.
- *Modifiers* add the fullest possible description to a particular wetland or deepwater habitat. Any or all of five modifier categories may be used, as required. The categories, and a few examples of each, are listed below (See Appendix A for definitions of the examples below.):

Water Regime Modifiers - Permanently flooded, Saturated, Temporarily flooded, etc.

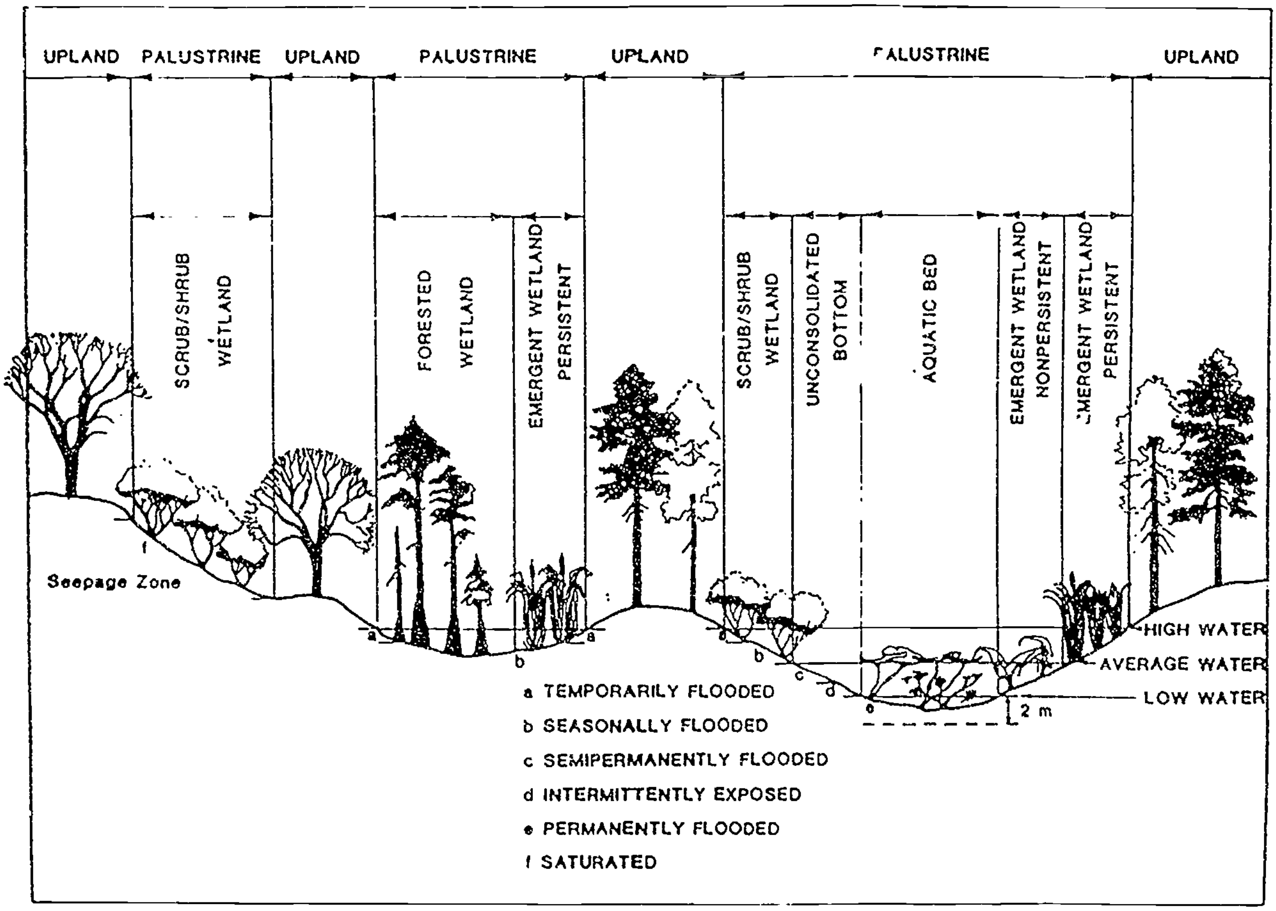
Water Chemistry Modifiers - Saline, Brackish, Fresh, etc.

Soil Modifiers - Mineral soil and *Organic soil.*

pH Modifiers - Acid, Circumneutral, and *Alkaline.*

Special Modifiers - Excavated, Farmed, *Diked*, Partially Drained, etc.

Figure 13: Distinguishing Features and Examples in the Palustrine System (Adapted from Cowardin et al. 1979, 9).



The wetland- and deepwater-classification scheme provides a systematic, scientific method for categorizing these habitats, as they exist anywhere on the surface of our planet Earth. Either from photographs or from personal observation, the buttressed bald cypress (*Taxodium distichum*) swamps, characteristic of southeastern U. S., are probably as familiar to us as any other wetland habitat. Putting the entire classification scheme together, a bald cypress swamp might be thoroughly described as:

SYSTEM Palustrine, CLASS Forested Wetland, SUBCLASS Needle-leafed Deciduous, DOMINANCE TYPE *Taxodium distichum*, WATER REGIME Permanently Flooded, WATER

Functions and Values of Wetlands

Before we begin our investigation of wetland functions and values, we must establish an understanding of the terminology used herein. What do we mean by a wetland *function*? How is a function different from a wetland *value*?

Most, if not all scientific works on wetlands, differentiate value and function similarly. *Value* connotes an anthropocentric (human) orientation, whereas *function* refers to an ecological process. Although such definitions assist authors in organizing and presenting material to the reader, we believe this approach can unintentionally cause a misunderstanding about what is, arguably, the most important fundamental fact regarding wetlands: wetlands have an *ecological value* that far exceeds any and all anthropocentric values, and many of the ecological processes, or *functions*, of wetlands create conditions of tremendous *anthropocentric value*. In other words, wetlands are not simply valuable in monetary terms; wetlands are valuable because they are unique ecosystems upon which many forms of life, including human, directly or indirectly depend. In this sense, wetlands are more than valuable; they are invaluable. Wetlands are precious resources that have taken nature millennia to create, are made even more precious by their rarity (6 percent of the Earth's land surface), and are vulnerable to adverse human use. These factors add to the ecological and anthropocentric worth of wetlands. The greatest value of wetlands, esoteric though it may be, is that nature has created them, just as nature will ultimately cause them to die by natural processes.

One other critical point to consider before we discuss the specific functions and values of wetlands is: different wetlands, both individually and as a specific type (as defined by system, subsystem and class), serve differing ecological and anthropocentric functions and values. Here, we shall simply list many known wetland functions and values. As an aid to individual thought, group discussion, and the learning process in general, the reader must conclude which functions and values apply to any given wetland or specific wetland type.

The reader will also be able to ascertain whether a listed wetland quality is a *function*, or whether it is a *value*, or whether it is both; whether the function or value is ecological or anthropocentric; and whether the function or value is of local, regional, or global significance. Some will be obvious, others will not be. In accordance with this idea, we have arranged the following qualities alphabetically rather than by any categorization scheme:

- **Aesthetics**: Aesthetic value, often closely linked to recreational use, is highly subjective. People are increasingly appreciating all types of wetlands for their natural beauty. An emerging industry, known as *ecotourism*, exemplifies our growing respect and appreciation for the aesthetic quality of our natural surroundings, of which wetlands are an integral part.
- **Atmospheric Processes**: Plant *metabolism* contributes to the stability of Earth's atmosphere in a variety of ways. Twenty-one percent of the Earth's atmosphere is oxygen, a byproduct of photosynthesis by plants and algae. Wetlands around the world produce enormous quantities of oxygen. Of lesser, but notable, significance is the wetland role regarding nitrogen. Because nitrogen accounts for 78 percent of the total volume of our atmosphere (the role of wetland nitrogen cycles pales in comparison to the importance of wetland oxygen output, atmospheric nitrogen use by *nitrogen-fixing plants* and the return of nitrogen to the atmosphere through the process of dentification are important cycles occurring within the wetland environment.
- **Aquaculture**: Natural and artificially-designed wetlands benefit many aquacultural industries. These include harvesting fish, shellfish, rice, cranberries, blueberries, and other food products.

- **Education and Research:** Wetlands provide a myriad of educational opportunities and research topics, many of which appear within this publication. Innumerable volumes of wetland and wetland-related literature are in print. The educational aspect we wish to emphasize here, however, is the value of on-site studies. Consider a three-acre (1.215 ha) marsh flooded to a depth of one foot (.304 m). One cannot fully appreciate its one million gallons of water and abounding life-forms without seeing it in person. One need only ponder the words of noted biologist, James G. Needham, to grasp its import: "It is a monstrous abuse of the science of biology to teach it only in the laboratory. ... Life belongs in the fields, in the ponds, on the mountains, and by the seashore." As with the science of biology, the same can be said of every other scientific discipline needed to study the wetland ecosystem.

- **Erosion and Flood Control:** Wetlands, both natural and artificially-designed, serve to minimize potential flooding by temporarily containing excessive runoff resulting from heavy rainfall, snowmelt, or high water discharge from adjacent streams. By decreasing flood-crest levels, wetlands reduce the degree of potential flood damage. Urban areas are, by their very nature, prone to the greatest monetary flood damage. The impermeable urban landscape is a major contributing factor for flooding and flood damage. Asphalt and concrete greatly increase water runoff; however, wetlands adjacent to, or contained within, the urban landscape serve to counter the impermeable urban landscape.

  Wetlands also help reduce the degree of erosion caused by flood waters by diminishing their velocity. As the velocity of flood waters retained by wetlands decreases, some portion of the sediment load settles from the water, thereby improving the water quality of downstream discharge. In addition, the volume of downstream discharge is less than the original water input because absorption and *evapotranspiration* remove some of the water from the wetland.

- **Groundwater Recharge:** Not all wetlands contribute to the process of groundwater recharge; however, the relative importance of this wetlands function is that recharge groundwater varies greatly with location. It is a complex relationship involving the local and regional topography, soils, underlying geologic *strata*, season, precipitation, and other factors. For example, the groundwater system of coastal areas is affected little, if at all, by the presence of wetlands. In the once-glaciated lake regions of Wisconsin, however, 26 percent of the wetlands play a role in groundwater recharge.

- **Filtration of Mine Drainage:** Mining operations, such as coal and various ore-extraction activities, expose innumerable natural elements (heavy metals) and other natural chemical compounds that otherwise would not readily find their way into *surface water*. By their chemical nature, many of these elements or compounds are *acidic*, thereby adversely affecting the *pH* level of the water in which they occur. In addition to the adverse environmental effects of increased acidity, some of the elements associated with mine drainage are known to have direct and harmful effects on human health. One example is the heavy metal, lead (Pb), which affects the mental acuity of humans, particularly children.

  Wetlands relate to the mine drainage dilemma by serving as important systems of filtration for suspended and dissolved mine drainage components. Filtration is a function of vegetation and the physical and bacterial processes of wetland soils. In some instances, the elements and compounds are not physically filtered from the water but are chemically transformed by one or more of the chemical or biochemical processes inherent to the wetland ecosystem. Strategically placed, artificially-designed wetlands are playing an increasingly important role in countering the adverse effects of acid mine drainage in many mining communities.

- **Natural Habitat**: Wetlands provide a habitat for mammalian wildlife, birds, amphibians, reptiles, fish, hydrophytes, and a myriad of lower life forms, all of which exist interdependently. Many wetland plant species exist only within the wetland environment. Certain plant species inhabit no other environment than the wetland, but creatures as diverse as beavers, alligators, and ducks could not survive without wetlands. Scientists have estimated that 150 bird species and 200 fish species depend absolutely upon wetlands.

  Wetland scientists have coined the phrase *protein factory* for the subject of their study and research. The term has obviously derived from the prolific nature of the wetland inhabitants and the conditions of the wetlands that make such proliferation possible. During the vegetative growth season, in particular, wetlands are highly productive. The abundant supply of available energy within the wetland ecosystem generates new life. Sunlight fuels the growth and proliferation of plants and algae while the decay of dead plant and animal life continually recycles nutrients.

- **Peat Mining**: Peat is an organic soil consisting largely of undecomposed organic matter that accumulated under conditions of excessive moisture over prolonged periods of time. Although not all wetlands provide the necessary conditions for peat development, peat can result from wetland dynamics. Essentially, peat is a by-product of wetland or wetland-like conditions. Its lengthy accumulation and maturation period qualifies peat as a nonrenewable resource with global reserves (Farnham 1979) estimated at nearly 796 million acres (322 million ha). Predominantly a horticultural product in the United States, peat is used as an energy source in many other parts of the world, particularly Europe and countries of the former Soviet Union. The measure of peat reserves in terms of acreage fails in that volumetric estimations would be far more meaningful. The depth of peat development, however, varies locally from a few inches or centimeters to many feet or meters, making volumetric estimations unreliable. The estimated acreage would suggest that peat reserves are abundant and that the continuation of properly managed peat mining is an acceptable practice. The environmental issue regarding peat mining is not the extraction of a nonrenewable resource but one of wetland ecosystem destruction.

- **Recreation**: The diverse types and sizes of wetlands provide equally diverse recreational opportunities, whether the wetland is a small farm pond as a place for fishing or small game hunting, or a large wetland preserved as a state or national park for camping, boating, and hiking. These recreational activities also provide economic opportunity for nearby businesses associated with servicing recreational areas.

- **Timber Production**: The total U.S. wetland timber crop is estimated at 82 million acres (33.2 million ha). Its geographic distribution is widespread, with two-thirds growing east of the Rocky Mountains. Most of the acreage is within the deciduous-bottomland hardwood and cypress swamps of the southeastern U.S. and within the evergreen-forested wetlands of the northern tier states. As timber prices continue to rise, and as land becomes increasingly valuable for agricultural, residential, commercial, and industrial use, these wetlands are being *drained* and exploited for their timber. Continued timber harvesting demands sound management and conservation measures for the present and the future.

- **Water Quality:** As previously mentioned, wetlands are excellent filtration systems, capable of removing suspended and dissolved chemicals from the water passing through them. Some communities are now collocating artificial wetlands with their conventional mechanical treatment systems. More than 150 municipal and industrial artificial wetlands are now treating sewage in the U.S. Enhanced water quality by way of natural wetland processes reduces the demand placed on the engineered filtration systems of conventional design. "If artificial marshlands were just better for the environment but cost the same as conventional mechanical treatment plants, it is doubtful that the technology would now be utilized. But the systems are also extremely economical (Gillette 1992, 12)" The economic importance of wetland filtration is now being widely recognized and exploited.

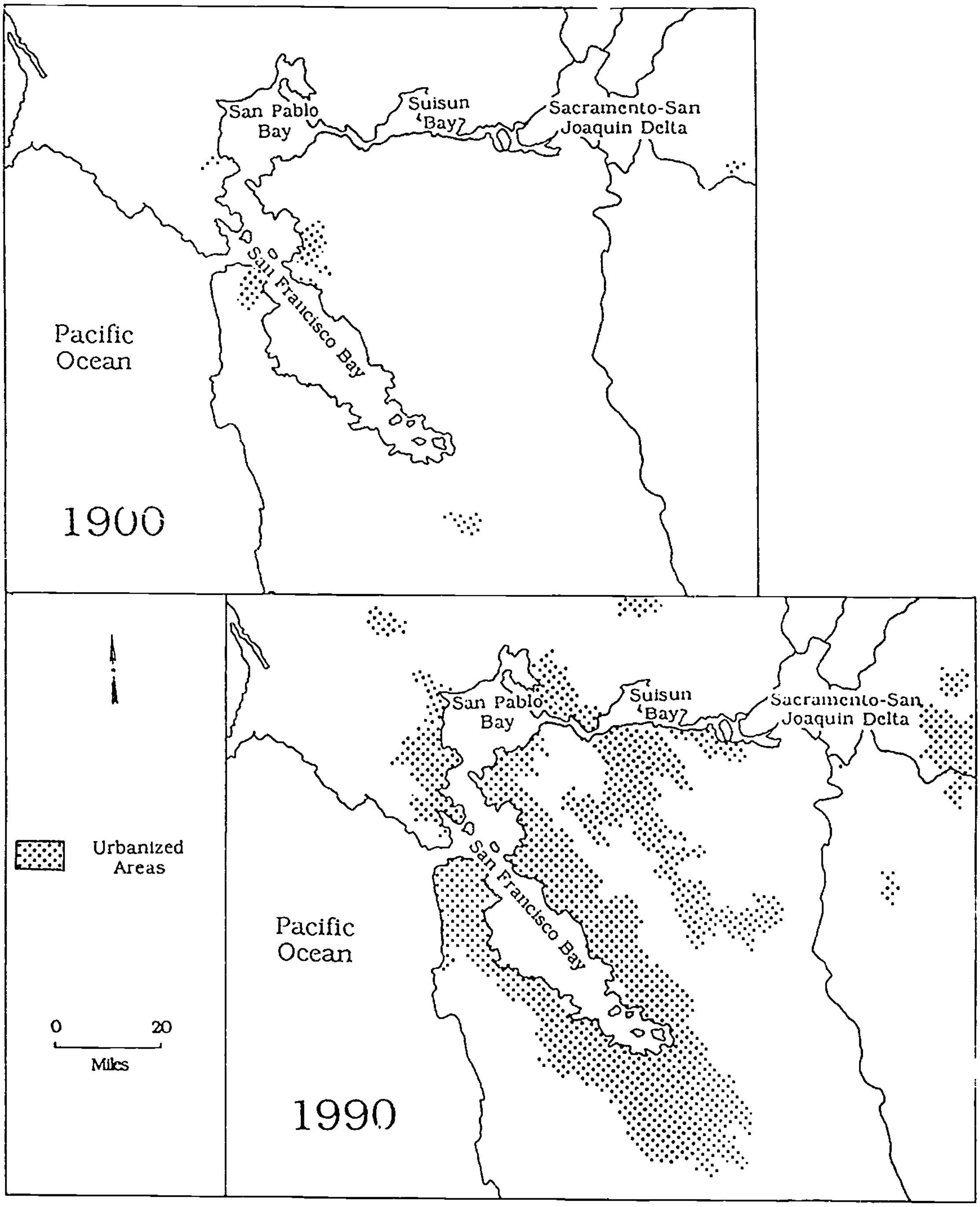
San Francisco Bay Area

San Francisco Bay was formed around 2000 years ago primarily as a result of tectonic activity within the region. This area includes the San Pablo and Suisun Bays as subsections of the San Francisco Bay (fig. 14). At its peak size in the mid 1900s the bay waters covered approximately 475 square miles plus an additional 315 square miles of tidal marshes. The bay drains about 40 percent of California through rivers such as the Feather, Sacramento, American, and San Joaquin. The Feather and American Rivers flow southward from the Sierra Nevada into the Sacramento River, and form a massive delta where it converges with the San Joaquin River that flows northward through the San Joaquin Valley (part of the Central Valley of California). From here, Sacramento River water flows westward into the Suisun Bay, San Pablo Bay, San Francisco Bay, and eventually into the Pacific Ocean. The Sacramento-San Joaquin delta is the primary source of fresh water into the bay.

Human settlement and land use practices are the primary stresses for both the San Francisco Bay and the Sacramento-San Joaquin Delta (fig. 15). Since the middle of the nineteenth century when hydraulic mining in the Sierra Nevadas began, more than a billion cubic yards of sediment had been discharged into the drainage basin of the Central Valley region. The Central Valley region eventually drains into the San Francisco Bay region and thus much of the sediments originally produced in the Sierra Nevada eventually were deposited into the San Francisco Bay. It is estimated that sediment deposits reduced the bay area from an original 475 square miles (1,230.25 sq km) to little more than 420 square miles (1,087.8 sq km). In addition, the coastal marshes and wetland areas, which naturally act as filters of sediment, decreased from 315 square miles (815.85 sq km) to less than 60 square miles (155.4 sq km). Only 6 percent of the original San Francisco Bay wetland area remains today.

As the city of San Francisco and surrounding communities grew, so did pressures on the bay and land surrounding it increase. As a result, approximately 12 percent of the total

Figure 14: San Francisco Bay Area



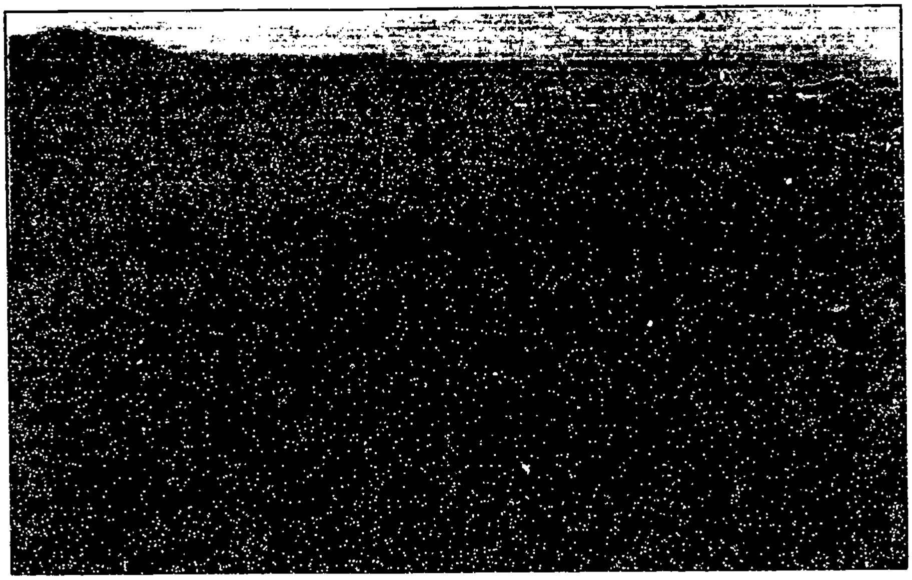


Figure 15: San Francisco Bay - San Francisco Bay has lost vast wetland areas because of sediment deposits and filling in of the bay. Efforts to reduce bank erosion shown in the photograph should restore some of the wetlands destroyed in the past.

water area and 80 percent of the marshes have been filled in for various land uses.

Approximately 7 million people live around the San Francisco Bay creating a massive burden on water quality and associated ecosystems. Since 1969, with the passage of the McAlteer-Petris Bill, unrestricted dumping of wastes into the bay has been illegal. Today, however, more than 200 industries and municipalities have permits to discharge waste material into the bay. The close proximity of high density land development has also resulted in nearly 185 tons of toxic trace metals and 30 thousand tons of hydrocarbon runoff to end up in the bay each year.

The Sacramento-San Joaquin Delta, the convergence of the Central Valley Drainage Basin, covers approximately 700 thousand acres (283 thousand ha). Nearly 40 percent of California lies within the drainage basin. Approximately two-thirds of the water used in California, including 40 percent of its drinking water originates from the Sacramento-San Joaquin Delta. Because of the 5 to 9 million acre feet of water drawn from this delta, increasing salt water intrusion is taking place. As less fresh water discharges into the bay, salt water is now moving into Suisun Bay, changing the salinity of it, as well as salinifying portions of the delta.

Along with this damage and the corresponding effects on the bay itself, the federal government has sued the state of California for violations of the Federal Clean Water Act and the Endangered Species Act and is mandating decreases in water withdrawals. Additional restrictions on water pollutants are coming into effect as well as a number of private interest groups that monitor compliance and heighten awareness of the water quality of the bay and its tributaries.

Wetland Identification and Delineation

Wetland identification and delineation is a complex, scientific process used to establish whether a wetland exists at a given site; to define the precise boundary of that wetland through detailed analysis of available data or by onsite investigation; and to *map* the wetland for future reference. By delimiting the *areal extent* of the wetland, we can meet the ultimate objective of identification and delineation, i.e., to prevent adverse human interaction with the wetland ecosystem.

The U.S. Fish and Wildlife Service (FWS) is responsible for generating and maintaining National Wetland Inventory (NWI) maps. Although the NWI maps serve as invaluable tools for the preservation of wetlands and as a preventive measure to avert potentially adverse and illegal land use activities, the FWS mapping project is far from complete. The NWI does not generate maps from precise on-site investigation but from aerial photographs. This procedure generates 1: 24,000 scale NWI maps (1: 63,350 for Alaska). The 1: 24,000 map scale is practical, manageable, and in common use for many other geographical purposes other than wetland mapping, but the scale is insufficiently detailed for accurate delineation of wetland areas. In this sense, NWI maps serve only to identify the general wetland area. Where any type of proposed engineering project potentially jeopardizes a wetland ecosystem, detailed on-site investigation remains necessary. The 1: 24,000 maps are estimated to have only 95 percent accuracy for delineating wetlands. The smaller-scale Alaskan maps have no value for delineation, but they can generally identify wetland areas.

The general public can assist the U.S. Fish and Wildlife Service and the NWI mapping process. Professional and academic wetland research teams, school science-project participants, conscientious and knowledgeable agriculturists, land owners and developers, and other members of society can assist the FWS by alerting them of potential wetland areas not yet identified by FWS's mapping efforts. One may choose to notify the FWS of a suspected wetland area or provide detailed field information to the FWS. The identification and delineation process can be laborious, even for the smallest of wetlands. The personal satisfaction gained by assisting in the discovery and the preservation of a wetland can far outweigh the energy expended. Precisely how much detailed information a wetland investigator provides depends upon a working knowledge of the identification and delineation process and the availability of and sufficient expertise in using essential documents and field equipment. Certain wetland identification procedures require considerable expertise, such as interpreting aerial photographs and satellite images. Even the most novice wetland investigator, however, can conduct a basic wetland identification and delineation project when given sufficient guidance.

The forthcoming identification and delineation procedure can provide a framework for informal wetland investigations, such as biological science and earth science projects. It is not for official use. Official procedures are contained in the *1989 Federal Manual for Identifying and Delineating Jurisdictional Wetlands*. We modeled our informal procedure from the federal manual, but omitted many details of the official procedures. The procedure still has considerable academic value and can supply potentially useful information to the FWS.

The federal manual describes three basic on-site methods of identification and delineation: (1) routine, (2) intermediate-level, and (3) comprehensive along with several variations of each. The following wetland identification and delineation procedure is a highly-simplified modification of an intermediate-level method as described within the federal manual. We chose this intermediate-level method because it requires the use of transect lines to partition the area being investigated, is more efficient for accommodating group work, and can be modified without appreciable loss to the educational benefit of conducting a wetland identification and delineation project.[1]

[1]Use of the federal manual has reportedly helped improve the enforcement of wetlands regulations; the Ecological Society of America (ESA) and others, however, are challenging the scientific basis of the manual. The major premise of the ESA challenge is that the 1989 manual "arbitrarily" establishes a frequency and duration of *inundation* (15 consecutive days) or soil saturation (21 consecutive days). ESA contends that "Previous definitions of wetlands have avoided such specificity regarding frequency and duration, recognizing the [scientific] knowledge of wetland hydrology is insufficient to establish such limits. (Holland 1992, 237)."

Wetland Identification and Delineation: An Academic Project

Initial Preparation

- Review the previous parts of this publication: "Geographic Relationships of Wetlands," "Definitions of Wetlands," "Wetland Systems (Classifications)," and "Functions and Values of Wetlands."
- Determine and acquire the necessary equipment and materials listed in figs. 16 and 17.
- Using plant identification field guides or manuals, review the fundamentals of plant identification and become familiar with the photos or sketches of hydrophytes indigenous to the region of investigation.
- Read the instructions contained within the Munsell Soil Color Charts booklet and review Appendix C, "How to use the Munsell Soil Color Charts."
- Review Appendix D, "Technical Criteria: Hydrophytic Vegetation, Hydric Soils and Hydrology."
- Estimate the project boundary using the pertinent resources, e.g., aerial photos, topographic maps, soil survey data, and delimit the approximate wetland area on a map or photo.

Steps for On-site Investigation

1. Locate the approximate limits of the project area and conduct a general reconnaissance of the area.
2. Establish a baseline for locating sampling transects. The baseline should be outside of the approximate wetland area and more or less parallel to the major watercourse through the area if one is present. If a watercourse is absent, the baseline should be placed on, and approximately parallel to, the higher ground (e.g., perpendicular to the downhill slope, or hydrologic gradient) and outside of the approximate wetland area. A road, power line, or other conspicuous map or site feature makes an excellent baseline if it meets the baseline-establishment criteria above. If a road qualifies as a baseline, for safety reasons plot the baseline parallel to but away from the road, using marking tape.
3. Determine the required number and positions of transects. For academic purposes, determine the number of transects based on the size of the project relative to the number of personnel (groups) participating in the project. Note, however, that official procedures call for approximately three transects per one mile of baseline, never to exceed one-half mile between transects under any circumstance. Transect positions should include all plant community types (e.g., mature trees, saplings, shrubs, herbs) and minor topographic variations (e.g., small rises, depressions).
4. Divide participants into groups and assign groups to individual transects. Each group walks the entire length of the transect, placing marking flags where the more obvious variations in vegetation occur along the transect. (In general, like and related species tend to cluster where proper conditions exist for their growth or global significance.) Some will be obvious; others may not be. In accordance with this idea, we have arranged the following qualities alphabetically rather than by any categorization scheme.

Figure 16: Suggested Equipment and Additional Materials for Onsite Use

Clipboards
Data forms (Appendix D)
Base (topographic) Map copies
National Wetlands Inventory map
County hydric soil map unit list
National List of Scientific Plant Names
Munsell Soil Color Charts
Soil auger or spade
Penknife
Binoculars
Waterproof footgear
First-aid kit
Insect repellent
Pencils
Field notebook
Aerial photograph copies
County Soil Survey or other map
Applicable federal wetland plant list
Plant identification field guides
Flagging tape, wire flags, and wooden stakes
Sighting compass
Camera and film
Tape measure
Drinking water
Sample collection bags

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5. Determine whether normal, undisturbed environmental conditions exist. If not, remember that official wetland identification and delineation procedures call for a supplemental "Disturbed Area and Problem Area Wetland Determination" assessment. For academic purposes, simply consider and note whether such conditions exist but proceed with the prescribed assessment technique.[2] Describe the type of alteration, such as grazing damage, irrigation canals, placement of fill material, removal of the original soil, bulldozing or plowing, clear-cutting, buildings, artificial levees, beaver dams, and roads. Abnormal conditions may include such things as unseasonable fluctuations in temperature and precipitation. You must also consider the seasonality of plant growth.
6. Characterize the plant community(ies) along the transect. Assess and record the information called for on the Data Form (Appendix E). Gross approximations of areal coverage by specific plant species are adequate for our purposes; the official procedures for plant community characterization, however, are highly detailed and analytical.
7. Determine whether the hydrophytic vegetation criterion is met. When more than 50 percent of the dominant species in a specific area (flagged previously along the transect) have an indicator status of Obligate (OBL), Facultative Wet (FACW), or Facultative (FAC), hydrophytic vegetation is present (Appendix D).
8. Determine whether soils must be characterized. Examine the vegetative data collected for each specific area previously assessed where: all dominant species have an indicator status of

[2]The official "Disturbed Area and Problem Area Wetland Determination" procedures are beyond our scope, calling for detailed groundwater studies and other technical assessments.

Figure 17: Primary Sources of Helpful Materials

DATA	SOURCE
Topographic Maps	U.S. Geological Survey (UNITED STATESGS) (Call 1-800-UNITED STATES A-MAPS)
National Wetland Inventory	U.S. Fish and Wildlife Service (NWI) Maps(FWS) (Call 1-800-UNITED STATES A-MAPS)
County Soil Survey Reports	U.S. Department of Agriculture (UNITED STATESDA) Soil Conservation Service (SCS) District Offices
National Hydric Soils List	SCS National Office
State Hydric Soils List	SCS State Offices
County Hydric Soil Map Unit List	SCS District Offices
Flood Maps	Federal Emergency Management Agency (FEMA)
Aerial Photographs	Various federal, state and private sources
National List of Plant Species That Occur in Wetlands	Government Printing Office, Superintendent of Documents (Stock No. That 024-010-00682-0) Washington, DC 20402 (202) 783-3238
Regional lists of plants that occur in wetlands	National Technical Information Service 5285 Port Royal Road, Springfield, VA 22161 (703) 487-4650
National Wetland Plant Database	FWS
Stream Gauge Data	UNITED STATESGS and U.S. Army Corps of Engineers (CE) District Offices
Local Expertise	Universities, consultants, etc.

OBL, or all dominant species have an indicator status of OBL and FACW, and the wetland boundary is abrupt and obvious. For these areas, hydric soils are assumed to be present and do not require examination. You must examine the soils of areas where the above characteristics are lacking.

9. Determine whether the hydric soil criterion is met. Locate each specific area (those previously assessed for vegetation criterion) on the county soil survey map if possible, and determine the soil type indicated by the soil map. Using a soil auger, probe, or spade, make a hole at least 18 inches deep within each specific area. Examine the soil characteristics for each sample area, comparing them to the soil descriptions in the county soil survey report. If soil colors match those described for hydric soil in the report, then record the data and proceed to the next step. If not, evaluate the soil samples for the characteristics listed on the Data Form (Appendix E). Refer to the self-contained Munsell Soil Color Charts booklet instructions and Appendix C for assistance, if necessary.

10. Determine whether the wetland hydrology criterion is met. Examine the area for buttressed tree trunks, multiple tree trunks, drift lines (including accumulated leaf litter, etc.), water marks or stains on trees, scoured (washed out) surface areas, and other such indicators of wetland hydrology. The wetland hydrology criteria is met when:

a. one or more field indicators are materially present; or

b. available hydrologic records provide necessary evidence; or

c. the plant community is dominated by OBL, FACW, or FAC species, and the area's hydrology is not significantly disturbed.

If the area's hydrology is significantly disturbed, make the best possible determination of the degree of disruption through casual observation, i.e., visible drainage ditches or piles of landfill.

11. Make the wetland determination for each specific area assessed. If the specific area meets the hydrophytic vegetation, hydric soil, and wetland hydrology criteria, the area is considered wetland.

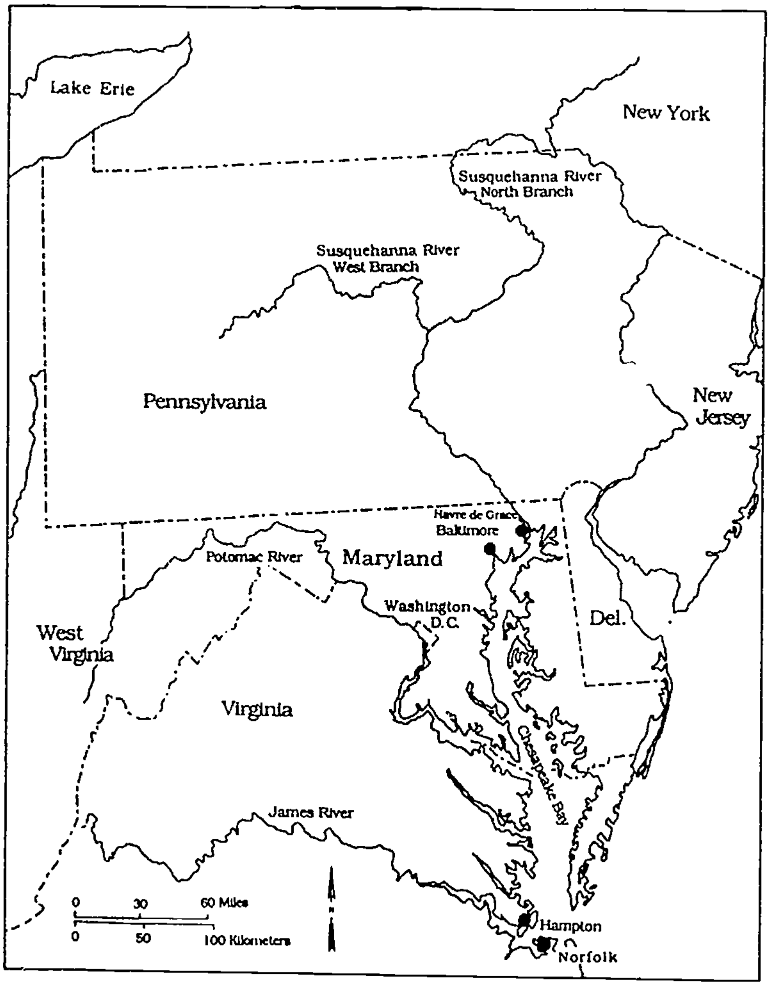
12. Determine the wetland-nonwetland boundary point along each transect. When the transect contains both wetland and nonwetland areas, then a boundary must be established. Proceed along the transect from the wetland plot toward the nonwetland plot. Look for the occurrence of Upland (UPL) species, subtle changes in hydrologic indicators, and slight changes in topography. For academic purposes, estimate the precise boundary point along the transect by superficial observation. If you desire more accurate determination, repeat Steps 6 through 11 until you establish the wetland-nonwetland boundary point. Mark the position of the wetland boundary point on the base map or photo and flag the boundary point in the field, as necessary.

13. Determine the wetland-nonwetland boundary for the entire project area. Delimit the entire wetland by extrapolating the boundary between all adjacent transects (using superficial observation as in Step 12) or by further refining the intertransect regions using Steps 6 through 11, as necessary.

The Chesapeake Bay

The Chesapeake Bay is one of the most productive estuaries in the world. The 64,000 square mile (165,760 sq km) drainage basin stretches from the Finger Lakes district in central New York, along the West and North Branches of the Susquehanna River in Pennsylvania, southwest from Havre de Grace, Maryland along the western shore to Hampton, Virginia and southeastward from Havre de Grace along the eastern shore to the southern tip of the Delmarva Peninsula (fig. 18). The watershed affords recreational and economic opportunities to more than 15 million inhabitants in the states adjacent to the bay.

Figure 18: Chesapeake Bay Watershed



The Environmental Protection Agency's 1983 study, "Chesapeake Bay: A Framework for Action," reviewed the effects of a growing population on water quality, wetlands, wildlife, and waterfowl. The increasing nutrient levels from nonpoint sources such as agriculture and atmospheric deposition were contributing to sedimentation and eutrophication of the Chesapeake Bay (fig. 19). Filling in of tidal and nontidal wetlands and deforestation were taking place at a rapid pace.

In designing a 1983 comprehensive Chesapeake Bay Program, the 1984 Maryland General Assembly passed The Chesapeake Bay Critical Protection Act to reduce the decline of the bay's environmentally sensitive areas such as wetlands and unique natural habitats. The law defined all lands within 1000 feet (303.23 m) of the tidal waters edge or from the landward edge of tidal wetlands as "critical areas." The critical areas amount to more than ten percent of the total land area in Maryland and include more than 60 local political subdivisions.

An innovative law such as The Chesapeake Bay Critical Protection Act of 1984 has outlined the goals of minimizing adverse effects on water quality, conserving fish and wildlife habitats, and establishing land use planning policies to reduce serious environmental damage. The minimum standards established by the Chesapeake Bay Critical Area Commis-

Figure 19: Chesapeake Bay Headwater Area. Chesapeake Bay efforts are underway to restore wetlands and reduce sedimentation and nutrient-rich runoff in streams such as the Middle Spring (shown in the photograph), part of the Susquehanna River and Chesapeake Bay drainage system. Recent passage of a Nutrient Management Bill in Pennsylvania was designed to reduce commercial fertilizer and manure management problems in Pennsylvania that would affect the Chesapeake Bay via the Susquehanna River drainage system.

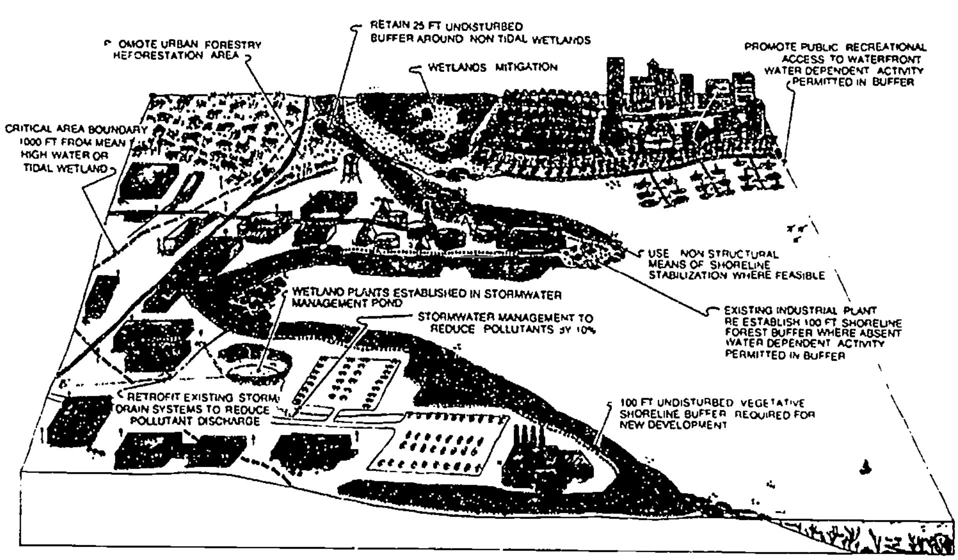
sion are to reduce residential density in Resource Conservation areas, to establish a Vegetated Buffer System around the bay to protect sensitive natural environments such as tidal and nontidal wetlands, and to ensure environmentally safe operations of surface mining, forestry, and agriculture.

The Critical Area Law required local municipalities to map and identify the following within local Critical Areas: Intensely Developed Areas, Limited Development Areas, and Resource Conservation Areas.

The Intensely Developed Areas (IDAs) include any area of 20 or more contiguous acres (8.1 ha) or the entire upland portion of a municipality within the Critical Area (whichever is less) where residential, commercial, institutional, or industrial land uses predominate, and where relatively little natural habitat occurs (Chesapeake Bay Critical Area Commission 1994, 8). Some of the following minimum standards have been designed for new development or redevelopment in the IDAs (fig. 20.):

- future intense development is encouraged to locate outside the Critical Area;
- new development or redevelopment should reduce pollutants entering waterways;
- a ten percent reduction in storm water pollutant loading and re-filtering for storm water management was designed;

Figure 20:



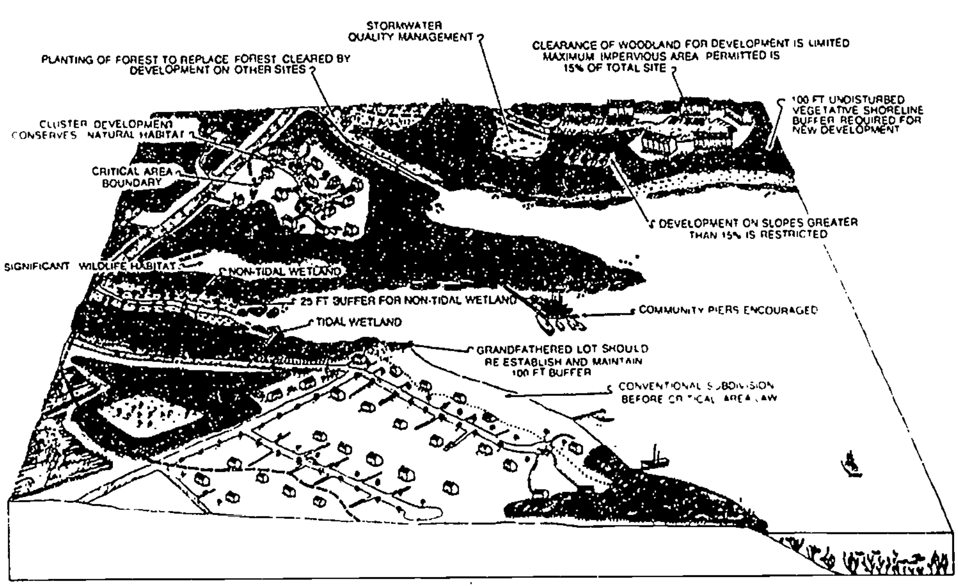
INTENSELY DEVELOPED AREA (IDA)
RESIDENTIAL, COMMERCIAL, INDUSTRIAL & INSTITUTIONAL USES DOMINATE

- public access to the shoreline should be maintained;
- the use of permeable surfaces should be used where possible; and
- the use of cluster development should be incorporated into the planning program.

Limited Development Areas (LDAs) are those areas currently developed in low or moderate intensity (Chesapeake Bay Critical Area Commission 1994, 10). Some of the following minimum standards have been designed for new development or redevelopment in the LDAs (fig. 21):

- new development must not change the prevailing condition of land use;
- wildlife corridors must be developed;
- total acreage of forest must be maintained;
- no development is allowed on slopes greater than 15 percent; and
- impervious surface coverage is limited to 15-25 percent.

Figure 21:



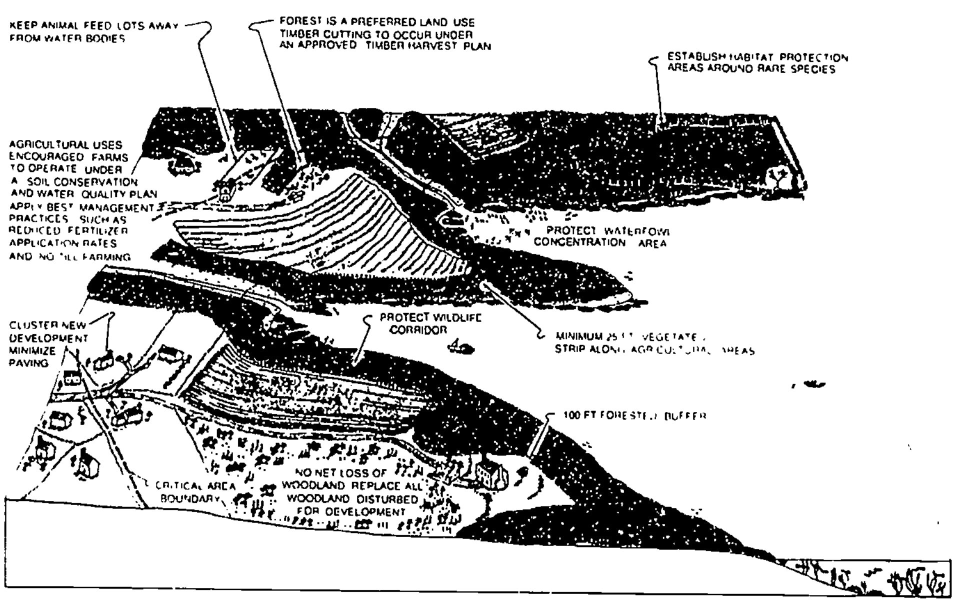
LIMITED DEVELOPMENT AREA (LDA)
CONSERVING NATURAL & CULTURAL LANDSCAPE

Resource Conservation Areas (RCAs) are characterized by nature-dominated environments, such as wetlands and forests or resource use activities such as agriculture, forestry, fishing activities, and aquaculture. (Chesapeake Bay Critical Area Commission 1994, 12). Some of the following standards have been designed for new development or redevelopment in the RCAs (fig. 22):

- New development density is to be limited to one dwelling unit per 20 acres (8.1 ha);
- All requirements for development within LDAs apply to RCAs; and
- New commercial and industrial facilities are not allowed in RCAs.

The Chesapeake Bay is a fragile environment that extends nearly 200 miles from Norfolk, Virginia at its mouth almost to the Pennsylvania line near Havre de Grace, Maryland. The natural communities of the bay are being protected for future generations by exemplary programs such as the Maryland Chesapeake Bay Critical Protection Act.

Figure 22:



RESOURCE CONSERVATION AREA (RCA)
NATURAL ENVIRONMENT PREDOMINATES

Conclusion

There is nothing permanent except change.
(*Heraclitis*, B.C. 535: 475)

For wetlands, the concern is not that change will occur. Change is inevitable, as Heraclitis recognized more than 2000 years ago. Rather, how and at what rate this change occurs is the focus of concern for wetland ecology. The "heedless pace of man," as Rachel Carson (1962) phrased it, is a threat and unacceptable to the balance of nature and its many ecosystems. Society's pace far exceeds nature's rate, often with devastating results in spite of nature's inherent resilience. In recent decades, the heedless pace of wetland loss has decelerated. Yet approximately 300,000 acres (121,457 ha) of wetland habitat continue to disappear annually in the United States.

The wetland regulatory objective within the United States centers on a no-net-loss philosophy — yet losses continue. Possibly more alarming than the continued loss of wetland habitat is a less obvious point: even if the no-net-loss objective was being met, which it is not, should we be content with merely halting further loss? Current wetland policy implies that past losses of some 118 million acres (47.8 million ha) of United States' wetland are irreversible, permanent, and unchangeable. This is not so. We are living in an era of growing environmental conscientiousness, one that is focusing on restoring many of our adversely-altered ecosystems. Can not and should not wetlands be approached with the same resolve?

> We are negative in our relationships with that which is of higher potential than we are; and we are positive in our relationships with that which has a lower potential. This is a relationship which is in a perpetual state of flux, and which varies at every separate point at which we make our innumerable contracts with our environment. (Kabbalah, B.C. 1200? or 700? A.D.)

Consider the final sentence from the Kabbalah. Rephrased with modern terminology, it contains all five fundamental themes of geography. The Kabbalah's relationship is today's human-environmental interactions. The reference to a perpetual state of flux is the geographic theme of movement. Lastly, every separate point is comparable to the remaining three themes: location, place, and region. By rephrasing the ancient sentence, we may conclude that some individuals for many hundreds of years appreciated the importance of geographic relationships to various environmental issues. When the majority of society accepts the fact that our environment is "of a higher potential" than we are, the relationship with our environment will cease to be negative.

4

LEARNING ACTIVITIES

A. WATER IN THE COMMUNITY

Peggy Hockersmith and Mary J. Shoemaker

GRADES K-6

INTRODUCTION

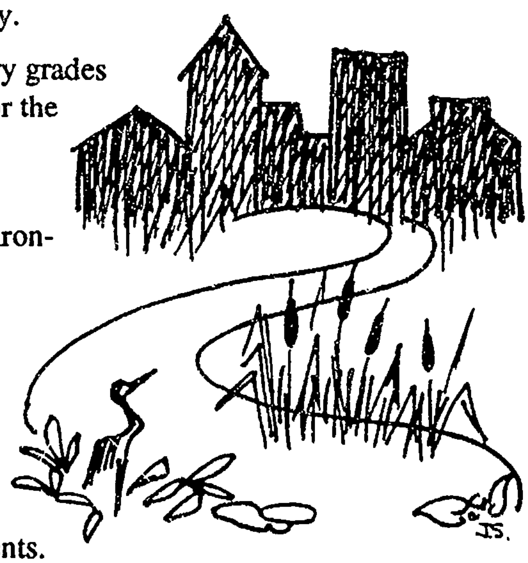
These lessons will focus on water in the community. They suggest a minimum of two weeks of activities for Kindergarten through grade six. All teachers and students should cooperate in a school-wide study of community interdependence of land use that concentrates specifically on wetlands. At the elementary level teachers must help students understand how the activities of each individual can affect wetlands. Long-term survival of all species and habitats maintains the variety essential for a healthy and complex environment. The culminating activity for the study of wetlands might be a school-wide Town Exhibition Day.

Grade Level: Five interdisciplinary activities for primary grades (K-3) and five lessons for intermediate grades (4-6) for the first week of activities; a list of expansion activities, a plan for the Town Exhibition Day (Week 2, K-6).

Themes or Key Ideas: Location, place, human and environmental relationships, responsibility

Concepts:

- Humans do not survive in isolation but as interdependent parts of all species and habitats.
- Humans have opportunities to ensure the survival of environments.
- Humans seriously influence the survival of environments.



Learning Outcomes: Students will:

- recognize characteristics of a wetland area;
- determine the different forms of life in wetlands;
- be able to compare and contrast the environment of a meadow from that of a wetland;
- understand terms related to wetlands;
- create a map of a wetlands area within a community;
- evaluate the importance of government on a local level;
- explore how they affect the environment;
- have opportunities to participate actively in a Town Wetlands meeting;
- understand the interconnectedness of water issues with the total environment;
- understand their role in teamwork.

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GUIDELINES FOR PRIMARY TEACHERS

- All activities are designed for cooperative learning groups. Teachers can easily incorporate suggested activities into whole language classrooms where the curriculum is integrated.
- Each group concentrates on a specific type of wetland (i.e., salt marsh, mud flat, wetland meadow).
- **Teaching time:** 30-50 minutes for each activity.

DAY 1. Wetland Vocabulary Building Activity

Based on the developmental needs of students, the teacher decides how many groups to form for the following activities. On the primary level these suggested activities are parts of lessons. The teacher will assign roles to students in groups (i.e., reporter, recorder). When needed, parent aides or teacher aides will assist.

1. Each group receives a picture of a specific wetland. Students determine geographical locations (different types of wetlands occur in different geographical locations).
2. Students brainstorm words associated with wetlands.
3. Students use words to construct group word boxes for their specific wetland.
4. Students insert words and drawings into group field journal. Field journals are teacher-made from sheets of experience chart paper.
5. Students share their group journal with other groups.
6. Students and teachers use these field journals as resources for other activities and shared them on Exhibition Day.

DAY 2. Wetland Classification Activity

Phase 1: EXPLORATION

Question: How many ways can you group these cards? Have students group cards in as many arrangements as possible.

Materials: Teacher supplies a set of 24 cards with pictures of plants, animals, and habitats, including those found in wetland areas. Card sets may contain uneven numbers of cards. The set used in the original lesson contained 6 cards for each of these habitats: wetlands, ocean, prairie, and forest. Each pair of students receives a data sheet with 20 blanks for possible groupings. The data sheet identifies exploration topic and students' names, and supplies twenty blanks to encourage creative grouping.

Time: 15-20 minutes

Procedures:

1. Students work in pairs with sets of cards.
2. Students separate cards into as many groups as possible.
3. Students use blank data sheets to record their environmental or habitat groups (e.g., aquatic and land; animal and habitats.
4. Students discuss their groupings with the entire class.

Phase 2: EXPLANATION

During explanation phase teacher may use textbooks, resource books, slides, or actual wetland items to increase student understanding and focus students' attention on the wetland habitat. If necessary, students can return to Phase I to continue grouping. Possible discussion questions:

- How did you divide your cards at each step?
- Did any teams group their cards in a similar fashion?
- What similarities did you notice among your cards?
- What differences did you notice among your cards?

For example:

- Why do you think __________ has these characteristics?
- Where do you think you would find __________ or things that have similar characteristics?
- Why did you group your cards in this manner?
- Does anyone have any other ideas to explain this?

Phase 3: EXPANSION

The expansion phase works best when students initiate questions to be investigated. Teacher provides sample questions and an activity here but could expand these in many different ways.

Question: What is a wetland? What are its functions?

- A water percolation activity uses tall glass jars (three-cup canning jars suggested) of soil from wetlands and other environments. Use water with food coloring added so students can monitor water absorption in different soil types.

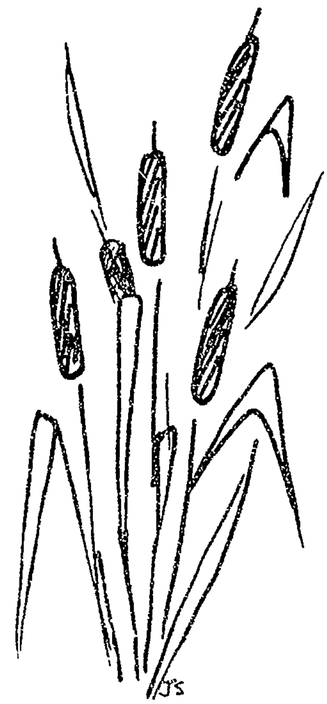
DAY 3: Collage of Land-use Activity

1. Teacher supplies poster board with specific type of wetland in the center. Each group uses a different type of wetland (i.e., wetlands that are characteristic of different parts of the United States).
2. Students paste pictures of human land-use activities around center picture. Students draw pictures or cut them from magazines.
3. Students place self-photograph somewhere on the wetland collage.
4. Students place vocabulary words from Day One on the collage. Students assess their work in field journal.
5. Students share wetland collages with others in class.

DAY 4: Wetland Process Writing Activity

1. Students work with partners to Think-Pair-Share about opportunities they might have to influence the environment.
2. Partners talk with each other about their wetland collages. Each person gets two minutes to talk while the other person listens. For example: Why did you place your picture where you did on your collage? How are you a part of the environment? How can you help save wetlands?

3. Partners question each other about their collages.
4. Students write stories or poems about wetlands.
5. Students read their stories and poems to other groups.
6. Students enter their writing into their field journals.
7. Students and teacher assess their wetland writings.



DAY 5: Wetland Mural Activity

1. Use large chart paper.
2. Each cooperative group becomes the expert on a specific type of wetland.
3. Each group sections its mural for illustrations by each group.
4. Students use vocabulary words from Day One to place near illustrations.
5. Groups discuss their murals with classmates.
6. Teacher may use completed mural to assess wetland understanding.

GUIDELINES FOR INTERMEDIATE ACTIVITIES

- All activities are designed to work with partners.
- Each partner receives a specific community role to investigate during the week.
- Activities should integrate all subject areas.

Teaching time: 45 minutes to all day; depends on library time required and on field study opportunities.

DAY 1: Wetlands Identification

(Make adaptations from Day Two of Primary Activities)

DAY 2: Identification of Aquatic Organisms and Community Map

Materials and people resources needed:

- Air photographs of the community
- Brochures from planning commissions or local government
- Resource people from colleges, zoning boards, or local government

1. Teacher selects the sites for students to gather local water samples while on a field trip of the local community.
2. Students take photographs of specific sites on trip. Students will use these later in a scrapbook activity.

3. Upon returning to classroom, students visit learning centers that include:
   - A map drawing activity of the community, i.e., flora, fauna, habitats, population, land use.
   - A microscope where they will assess the diversity of the water samples.
   - A data organizing center where students will graph population density of community and water samples of aquatic life.
4. Students will assess the activities in their field journals.

For example: What did I learn today about my role in ensuring the survival of the environment?

- What topics and ideas are important to know before I can seriously influence the quality of the environment?
- How do I rate my understanding of the interdependence of all species and habitats?

Expansion Activity :

- For interested students:
  - Sample streams upstream and downstream.
  - Identify most diverse and least diverse streams in area in terms of organisms, environment, flora, fauna, and land use.
  - Monitor temperature and velocity of streams.

DAY 3: Transition Day

1. Students complete learning center activities.
2. Students receive community role-playing cards. Give time to work with partner is establishing community goals.
3. Migration Headache Game from pages 87-91 of *Aquatic Project Wild* is highly recommended as an activity that integrates science, language arts, math, social studies, and physical education in an enjoyable way (45-minute period is needed).

DAY 4: Design a Community

1. Entire class designs an imaginary map to be used for the culminating activity during week two. The map should include:
   - Wetland area
   - Zoning of the area, especially in the community and around wetlands
   - Property ownership (specify who owns what)
2. Use "Planning for People and Wildlife" from pages 284-287 of *Project Wild.*

DAY 5: Lesson Plan for Local Government and Land Management

Anticipatory Set:

- Higher level question: "What could you do if your neighbor cut down all the trees in a wetland area to build a pig farm?"

Objectives:

1. Students will be able to list at least three local officials who influence land development.
2. Students will be able to formulate at least five questions about land management that assures public health, safety, and welfare.

Materials:

1. Subdivision plat maps from local planning board (one per three students)
2. Guide-to-observation sheets (one per student as in independent practice).
3. Page of prepared notes listing local officials and their role in land management (one per student). Teachers can obtain this information from planning commissions and zoning boards.
4. Labeled popsicle sticks representing officials (one pack per student).

Procedure:

1. Instructional: Teacher will distribute and present prepared notes.
2. Students will discuss each local official in notes, e.g., their duties and powers.
3. Teacher will describe a land management problem and then list the local officials who would participate in the solution.
4. Teacher will give each student one pack of labeled popsicle sticks. As teacher describes a land management situation, students will hold up the sticks(s) to indicate the specific officials involved.
5. Teacher will show a subdivision map to the class and point out significant features. Teacher will model a few questions related to the map. For example:
   - Why do you think the subdivision is divided the way it is?
   - Who is involved in making land-use decisions?
   - How do zoning laws affect the environment?
   - Do land use decision makers follow state and local ordinances?
6. Invite students to ask questions about the map.

Summary: Ask one group of students to review, summarize, and report to the class the roles and responsibilities of local officials who influence land development. Teacher asks the connecting question: "How could these officials protect wildlife habitats?"

Independent Practice: Group of three students will receive one plat map and each student will receive a guide-to-observation sheet. Observation sheet will list important elements of a subdivision such as locational characteristics, road frontage, lot size. Questions should include a range of skills form calculating acreage to student opinions on community health, safety, and welfare.

Evaluation: Using maps and working in the capacity of a planning board member, students will list two positive and two negative aspects of the subdivision and formulate three questions they may ask developer that will assure public health, safety, and welfare.

EXPANSION ACTIVITIES FOR SECOND WEEK

Introduction: Activities can be adapted for any grade level. Teachers might use these activities to build momentum for the culminating activity, A Town Exhibition Day.

Activities:

1. Scrapbook completion for Intermediate Level
2. Speech and sign activity for picketing at town meeting
3. Public opinion polls and petitions on wetland issues
4. Diagrams of local government roles in land management
5. Writing poetry, songs, chants, finger plays, or stories about environmental issues
6. Art activities inspired by studying wetlands for exhibit during Town Exhibition Day
7. Creating histograms of different types of migrating birds or prepare a map of their migration routes
8. Culminating activity

CULMINATING ACTIVITY (TOWN OR CITY EXHIBITION DAY)

(Last Day of Second Week)

Method: Role-playing activity: town, city council, or appropriate urban agency responsible for land management meeting regarding possible development of wetland area.

Background: Teachers and officials have discussed local government operations. Students have investigated and discussed conflict. Teacher has assigned roles to students. Students have developed their positions.

Materials:

- Map of wetland within community
- **Role assignments:** May include but not limited to several board members, farmers, homeowners, merchants, developer, landowner, banker, environmentally aware citizens, business people, realtor, president of chamber of commerce, unemployed citizens, wealthy neighbors of the proposed development site.
- Video camera

Procedure:

1. Arrange room for meeting.
2. Establish a chairperson to chair the meeting and have responsibility for maintaining order.
3. All students present their positions to the board.
4. Address questions or rebuttals.
5. Board members vote and explain decisions.
6. Discuss interactions afterwards as a class, e.g., allies and adversaries, responsibilities as individuals and community, importance of process for decision making, list pros and cons of format and results, compare classroom-real world situations, major issues that arose.

7. Students write about their personal experience, recommendations, or vote.
8. Videotape participants — use in assessment of activity and to introduce to another class the next year.

Source:

Western Association of Fish and Wildlife Agencies. 1983. *Project Wild: Secondary Activity Guide.* Boulder, Colo.: Western Regional Environmental Education Council.

Self, Peer, and Teacher Assessment: This two week unit adapts well to authentic forms of assessment. The assessment is on-going. Students use field journals to self-evaluate their participation and project completion. Students and teacher can assess the video questions that student's learning partner discusses and assesses, and teacher may ask the following:

- Was I pleased with my efforts on the project? Why or why not? Have others in my group thought that I cooperated and did my share of the work? If I could do this project again, what might I change? What was the most interesting activity? Why?
- What activity was the most difficult for me? Why? Do I feel wetlands are important? Have my feelings about environmental issues changed as a result of studying about wetlands?
- What role did I play in the Town Exhibition Day? Did I agree or disagree with this point of view?
- Some day I may be on a planning or zoning commission. What environmental issues might I confront?
- How can I help improve the environmental balance in my community?

Teacher and Student Evaluation: Student evaluates self first and then teacher evaluates the students. Together they discuss discrepancies in evaluation. In addition to these question, teachers may design test questions to ascertain knowledge gained from studying wetland issues.

- On the continuum below, where would you place yourself for participation in this unit?

  [ ] Poor [ ] Fair [ ] Good [ ] Excellent

- How would you rate your interest in etlands?

  [ ] Poor [ ] Fair [ ] Good [ ] Excellent

- How would you rate the presentation of your project(s)?

  [ ] Poor [ ] Fair [ ] Good [ ] Excellent

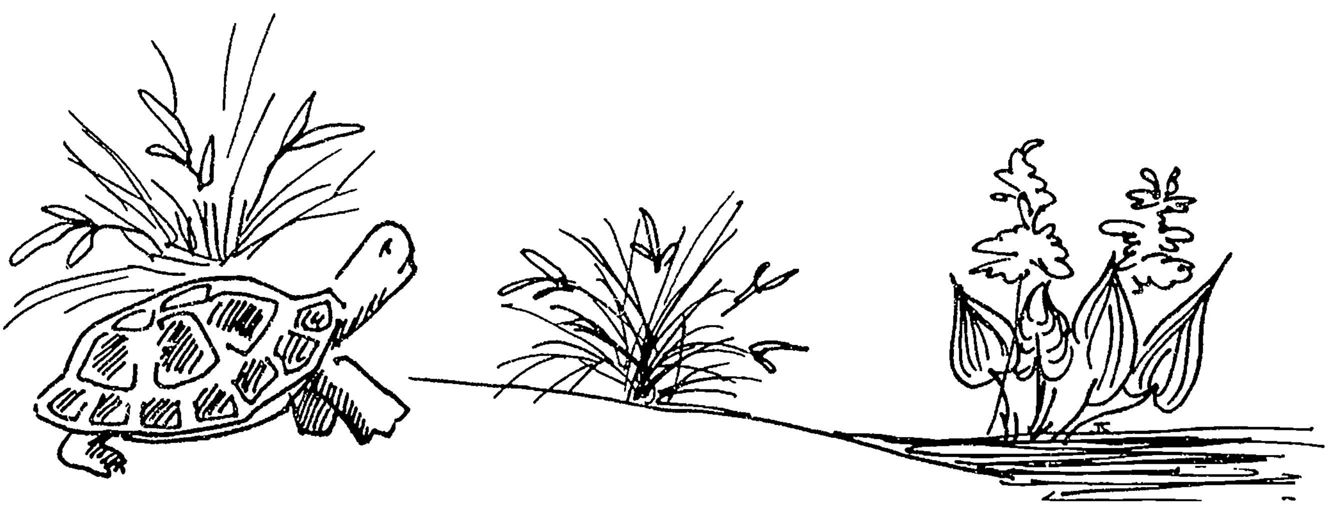
- How would you rate your understanding of the interdependency of humans, species and habitats?

  [ ] Poor [ ] Fair [ ] Good [ ] Excellent

- How much have you grown in your understanding or wetland issues?

  [ ] Poor [ ] Fair [ ] Good [ ] Excellent

- What must you do to increase your knowledge of environmental issues?
- What do you think are some of the major problems environmental planners face? Why?
- Have you discussed wetland issues with your parents? Why or why not?
- Do wetlands occur everywhere?
- What are similarities and differences between various wetland regions?
- What characteristics of wetlands did you find most interesting or surprising?
- What ways do local government decisions affect wetland environments?



B. WETLANDS FUNCTIONS, TYPES, DISTRIBUTION, AND CHANGE

Beverly Wagner

GRADES 7-9

PART 1: Wetland Functions: Are Wetlands Worth It?

INTRODUCTION

Wetlands are among our most valuable and unique natural resources. A wetland is an area between land and water where the water table is generally at or near the surface and the land is covered by shallow water. Wetlands must have soils that are saturated with water or be periodically inundated and have an abundance of plants that can live in wet soils or water.

A salt marsh is a wetland that provides an important environment between the land and salt water bodies. Fresh water and salt water meet here to form a unique habitat for wildlife. People, unfortunately, have often regarded salt marshes, like other wetlands, as wastelands — useless and mosquito-infested swamps or merely landing strips for ducks. Since the 1700s, the United States has lost more than half of its wetlands, and they are still disappearing. People have used them as dump sites and have drained and filled them for farming, roads, and housing developments.

In the following hands-on activities students will read about the functions of wetlands and the reasons for their destruction. They will review these functions and threats by associating the functions with objects familiar to them in everyday life. Finally, students will decide if wetlands are worth preserving.

Purpose: Using salt marshes as an example, student will develop an appreciation and understanding of wetlands as valuable and productive natural resources to human life as well as wildlife.

Suggested Grade Level: lesson could be adjusted for any grade level.

Time: One to two class periods.

Themes or Key Ideas: location, region, relationships within places, human and environment relationships

Concepts: wetland, marsh, plankton, detritus, and ecosystem.

Objectives: At the completion of the unit, students will be able to:

- Knowledge
  - ☐ Describe the natural functions of salt marshes (wetlands).
  - ☐ Understand the value of wetlands to humans and wildlife.
  - ☐ Identify ways in which humans are threatening wetlands.

- Skills:
  - Associate functions of wetlands with everyday objects.
  - Discuss the causes and consequences of destroying wetland areas.
  - Attitudes and Values:
  - Appreciate the need to protect wetlands to ensure a healthy and viable environment for all living beings.

Materials:

1. Salt Marsh Information Sheet and Figure 23: Nature's Sponge following this activity.
2. A bag (or box) large enough to hold the following items.
3. The following items which will be used to represent the natural functions of salt marshes. Relate these objects to concepts presented about wetlands in the Salt Marsh Information Sheet and Figure 23: Nature's Sponge provided for this activity:
   - **a sponge:** absorbs excess water caused by runoff
   - **a pillow:** provides a resting place for migratory birds.
   - **a beater or whisk:** mix nutrients and oxygen into the water.
   - **an oyster shell or toy crab:** provide a habitat or nursery that shelters, protects, and feeds wildlife.
   - **a sieve, filter, or strainer:** strain silt, debris, or other pollutants from water.
   - **an empty bottle of antacid:** neutralizes toxic substances.
   - **a box of cereal or bottle of vitamins:** provide nutrient-rich food for wildlife.
   - **a bar of soap:** helps cleanse the environment.
   - **a toy tractor:** represents the way humans destroy or create wetlands.
   - **a toy garbage can:** represents the way humans use wetlands for landfills or dumping sites.
   - **a toy bulldozer or house:** represent the way humans are draining wetlands for development.
   - **a paintbrush, camera, or toy boat:** represent recreational values of wetlands.

OR

   - 3"x5" cards on which pictures can be pasted if objects are not available

Procedure:

1. Ask the students what a wetland means to them. List their responses on the chalk board.
2. Read and discuss the characteristics of a salt marsh, as a valuable resource, and the methods taken for protecting salt marshes and other wetlands.
   - Show an appropriate video, if available.
3. Review the new terminology in the reading such as; marsh, plankton, detritus, ecosystem, and wetland.
4. To conclude the lesson, evaluate students' understanding of the discussion by using the bag of objects.

- Tell the students that everything in the bag has something to do with a wetland, specifically the salt marsh they just read about.
- Individual students take turns selecting objects form the bag.
- Each student is to describe the relationships between the object he or she chose and the wetland function or threat it represents.
- Encourage students to build on each other's ideas.

5. Ask the students if their attitudes about wetlands have changed since the lesson began.
6. Review with the students why our well-being requires salt marsh (wetland) ecosystems.

FOLLOW-UP ACTIVITIES:

1. Modify these activities to illustrate a freshwater marsh.
2. Visit and tour a wetland.
3. Investigate local, county, state, and federal regulations and laws that govern wetlands in your region of the country.
4. Invite speakers from wetland or environmental agencies into the classroom to speak to students.
5. Identify wetlands that exist in the community and evaluate the community's current land uses. Have students decide if public or private groups could define wetlands as environmentally sensitive areas and if wetland use complies with municipal land use regulations.
6. Make a simple model of a wetland to illustrate how wetlands work (see attached).

References:

Carlson, C., and Fowler, J. 1980. *The Salt Marsh of Southern New Jersey*. Pomona, N. J.: The Center for Environmental Research, Stockton State College, 1980.

U.S. Environmental Protection Agency. 1988. *America's Wetlands: Our Vital Link between Land and Water*. Washington, D.C.: Author.

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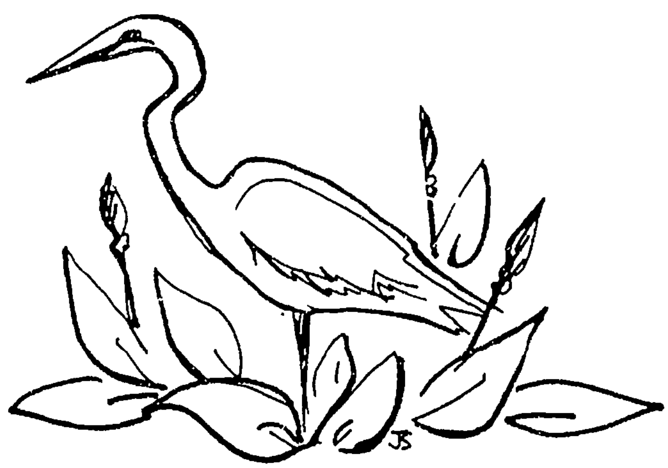


SALT MARSH INFORMATION SHEET

All wetlands, whether coastal or inland, provide unique habitats for wildlife. Wetlands are critical to the survival of a wide variety of animals and plants. Coastal wetlands are an especially unique environment because salt water and freshwater converge. Organisms found in salt marshes are more diverse and complex than in any other habitats because the two kinds of water mix. Salt marshes are extremely productive ecosystems, providing a wide variety of edible plants, fish, and game.

Grasses dominate the vegetation of the salt marsh. An abundance of plant life growing in the marsh forms the basis of the food web. Since these plants supply food at the lowest level of the food chain they are called primary producers. Bacteria promote the decay of the grasses and animal matter as old grasses die. New grass is always being produced. This decomposed matter, called detritus, is rich in nutrients. Detritus becomes the main food source for oysters and clams. These detritus eaters, in turn, serve as food for other animals including crabs, birds, and many varieties of fish. The greater the diversity of plant life found in the wetland, the higher numbers and more species of animals it will attract. Plants also contribute, through the process of photosyntheses, by mixing oxygen in the water, which provides food to other life forms.

At the next level of the food chain are the primary consumers, those who eat plants. These animals include rabbits, deer, other mammals, reptiles, amphibians, fish, geese, ducks, and other birds. Secondary consumers (meat eaters) eat primary consumers. These predators are birds of prey and people! Because of the abundance of vegetation cover and food sources, the salt marsh is a valuable habitat for diverse wildlife species.

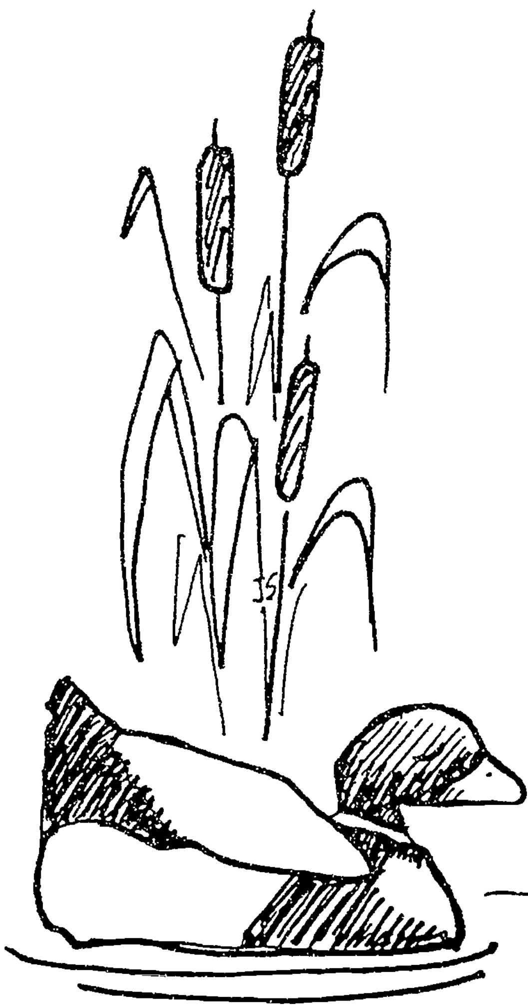
Thousands of migratory birds, including ducks, geese, cranes, and shore birds, depend on salt marshes for resting places. A great variety of fish species spend part, or all, of their life cycle in wetlands. Birds also depend on salt marshes for nesting areas. Because these marshes provide critical breeding and rearing habitats for wildlife, they are often referred to as nurseries.

In addition to providing valuable habitats and food resources to wildlife, the salt marsh is important for other reasons. Marshes are critical in their ability to help maintain and improve the water quality of rivers and streams. They filter nutrients, waste, and sediment from the surface runoff from the land before it reaches open water. They cleanse the water for fish and other aquatic animals. Marshes also neutralize sewage waste by cycling nutrients through the food web and keep nutrient concentrations from reaching toxic levels. Protecting marsh lands is vital to restoring and maintaining good water quality.

Wetlands have also been referred to as natural sponges that absorb flood waters. Salt marsh vegetation helps slow the velocity of flood waters. This action has three advantages: it recharges and stores groundwater; it reduces the risk of flooding; and acts as a buffer to the shoreland against erosion.

Finally, salt marshes provide recreational and aesthetic opportunities for people. They are natural treasures for the artist, the photographer, or those who enjoy observing nature. For people who like being near the water, wetlands provide hiking, swimming, boating, and fishing areas. Salt marshes also provide a dynamic classroom for teaching geography and environmental education.

Although salt marshes are resilient, they have limits in their ability to function. The salt marsh environment is continually threatened by coastal development and pollution. People are converting salt marshes to other uses such as dump sites, roadways, housing developments, and most of all, farming. Thousands of acres (hectares) a year are being drained, dredged or polluted. Much of the pressure is coming from the growing population centers upstream or near the coasts. Although federal and state laws protect many wetlands, a significant need exists to improve our understanding of the value of salt marshes as ecosystems and wildlife habitats and that they are worth protecting.



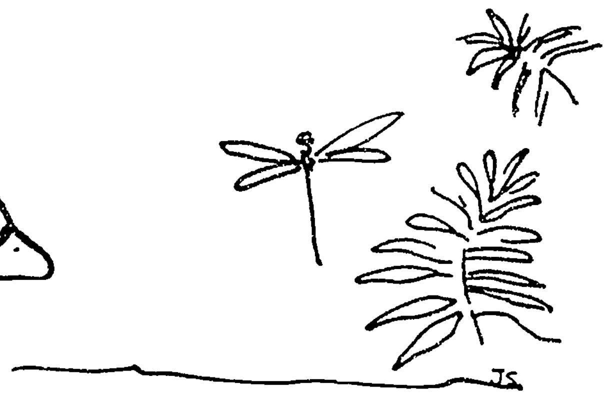
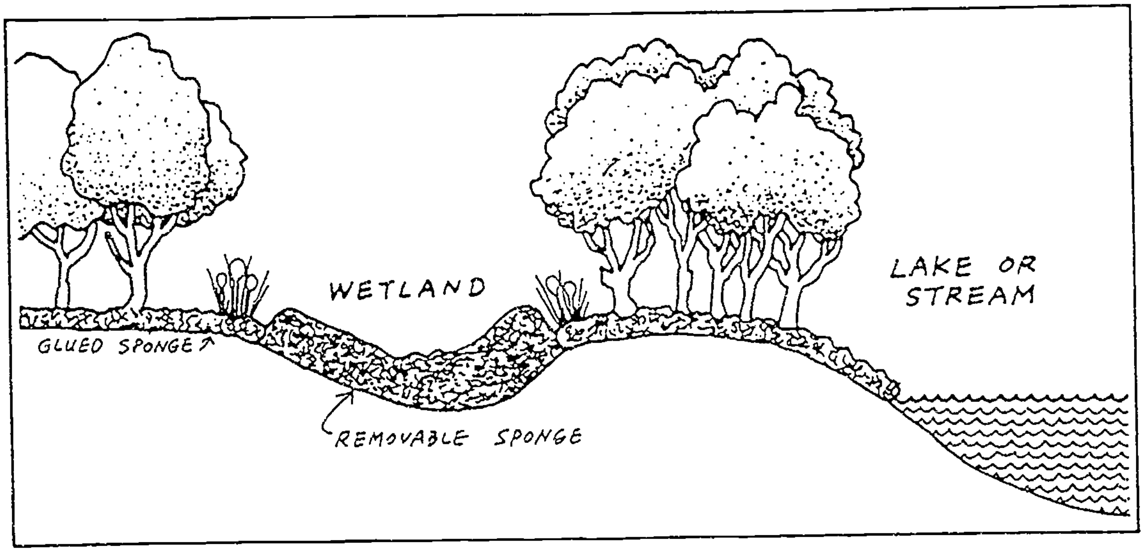


Figure 23: Nature's Sponges



Objective: Students will perceive the importance of wetlands in controlling flooding and purifying and replenishing water supplies.

Materials: Modeling clay, sponges, sticks, Q-tips®, glue, scissors, brown paint.

Time: Two to three hours

Our wetlands are nature's sponges. Unfortunately, their importance in controlling flooding, replenishing and purifying our water, and providing habitat has not been widely recognized.

Ask your students to think about a grassy meadow after a rain or when the snow melts in the spring. They will recall the soggy ground beneath their feet. See if they can think of any reasons why wetlands should be kept in their natural state. Do they have suggestions on how we should *use* these lands?

To help your students discover the important role of wetlands, have them build a mini-environment modeled on the drawing above. Use modeling clay to build the terrain. Then have students cut and then glue a thin layer of sponges onto the surface of the land, except on the wetland. Students can use sticks and pieces of green sponge to make trees, and Q-tips® colored brown for cattails. Have them make a *removable marsh* out of a thick piece of sponge to be inserted in the wetland depression. Be sure they do not glue this in place.

When they have completed the model, have them place the removable marsh in the depression and pour water onto the model at the point farthest from the lake. Watch how the *ground* absorbs the water and how the lake or stream slowly fills in. Now *drain* the wetland by removing the sponge. What happens when water is poured onto the model? How fast does the lake fill in? Pour on a good volume of water. Does the lake or stream *flood*? Is any water stored in the wetland depression for release later? Now place the wetland back in the depression. Pour muddy water onto the model. What color is the water that emerges into the lake? What happens when the wetland is removed? Should wetlands in nature be protected?

Nature's Sponges is taken from *Living Lightly in the City*, an interdisciplinary and environmental and conservation program. There are volumes for grades K-2, 3-6, and 7-9. For more information write to the Schlitz Audubon Center, 1111 East Brown Deer Road, Milwaukee, WI 53217.

PART 2: Types of Wetlands: Which Wetland Is Which?

INTRODUCTION

A wide variety of wetland types exist throughout the U.S. We can find some type of wetland in every county in every state of the United States. The different types of wetlands are classified by the vegetation that grows there. A variety of wetlands has formed across the country because of regional and local differences in hydrology, water chemistry, soils, topography, climate, and other factors. Wetlands appear in every climatic region of the country. Although their main characteristics are different, their functions remain exceedingly similar.

In the following activity students will discover the relationships between the types of wetlands in different regions of the United States and their location on the map. Also, students will learn that a number of significant wetlands across the United States have been identified because of their extensiveness and their importance in providing wildlife habitats.

Purpose: Students will become familiar with some major wetlands of the U.S., the major features of each type, and the kinds of places where they occur (fig. 24).

Suggested Grade Level: 7-12

Time: two or three class periods.

Themes or Key Ideas: location, place, and region

Concepts: marine, estuarine, riverine, lacustrine, and palustrine

Objectives: At the completior . the unit students will be able to:

- Knowledge:
  - Identify and locate some of the major wetlands across the country.
  - Learn the characteristics of major wetland types in the United States.
  - Compare characteristics of major U.S. wetlands with the physical characteristics of their locations.
- Skills:
  - Use resource materials to identify the major wetlands.
  - Use atlases to locate the wetlands on the map as well as to gather data.
- Attitude and Values:
  - Appreciate that wetlands can be found anywhere, and although their characteristics could differ, their functions remain the same.
  - Appreciate that each wetland and wetland type is special and unique and worth protecting.

Materials:

1. Activity sheet: "Wetland Types: Which Wetland Is Which?"
2. Outline map of the United States: activity sheet (fig. 25)
3. Thematic maps of the United States: political, physical, land-use, climate and population from a reputable atlas.
4. Clue cards (or a list of possible wetlands to investigate)

Procedure:

1. Read the information sheet describing the five major types of wetlands in the United States.
2. A number for each of the wetlands is marked on the United States map (fig. 24). Students are to match the names of the wetlands with the appropriate numbers on the map. If they do not know the answers to some of them they will investigate them using clues in the descriptions and atlases.
3. Information should include distinguishing characteristics in the clues: type of wetland, climate type of region, any interesting fact such as history, specialty crop, unique problem. As students are probably unfamiliar with wetland regions, a word list may be helpful from which students can choose when identifying major wetlands and matching the names to the locations on the map.
4. Write the name of the wetland in the space on the map.
5. Discuss the relationship of the wetland types with their location on the map.

LESSON EXTENSION

Extend the lesson to a global scale by investigating significant wetlands in different countries. Substitute the clues for the major U.S. wetlands with clues for major wetlands in other world regions.

REFERENCES

America's Wetlands: Our Vital Link between Land and Water. 1988. Washington, D. C.: U.S. Environmental Protection Agency.

Mitchell, John G. 1992. "Our Disappearing Wetlands." National Geographic. (October): 3-42.

MAJOR WETLAND TYPES IN THE UNITED STATES

The term wetlands describes, in a collective way, what we commonly know as swamps, bogs, marshes, wet meadows, shallow ponds, and any similar areas that develop between open water and dry land.

Plants, soil, and hydrology define a wetland. Wetlands have three major characteristics:

1. Land that is inundated or saturated by water at varying periods of the growing season.
2. The presence of water that creates favorable conditions for hydrophytes (plants especially adapted for water).
3. Hydric soil properties: soils that promote aquatic vegetation.

Wetlands receive their water from four possible sources: direct precipitation, runoff from surrounding lands, groundwater inflow, and lake water and ocean tide water. Almost all wetlands receive precipitation and runoff, but only certain areas receive groundwater and only coastal wetlands receive ocean or lake water.

We can separate wetlands into two broad categories: coastal wetlands and inland wetlands. Coastal wetlands are located along the Atlantic, Gulf, and Pacific coasts. These can be difficult environments for most plants because salt water mixes with fresh water. Because of this, many shallow coastal areas lack vegetation and become mud flats or sand flats. Coastal marshes are the exception because salt-loving grasses and plants have adapted to the saline water. Coastal marshes are commonly found along the Atlantic and Gulf coasts. Mangrove swamps, dominated by salt-loving shrubs and trees, are common in Hawaii and southern Florida.

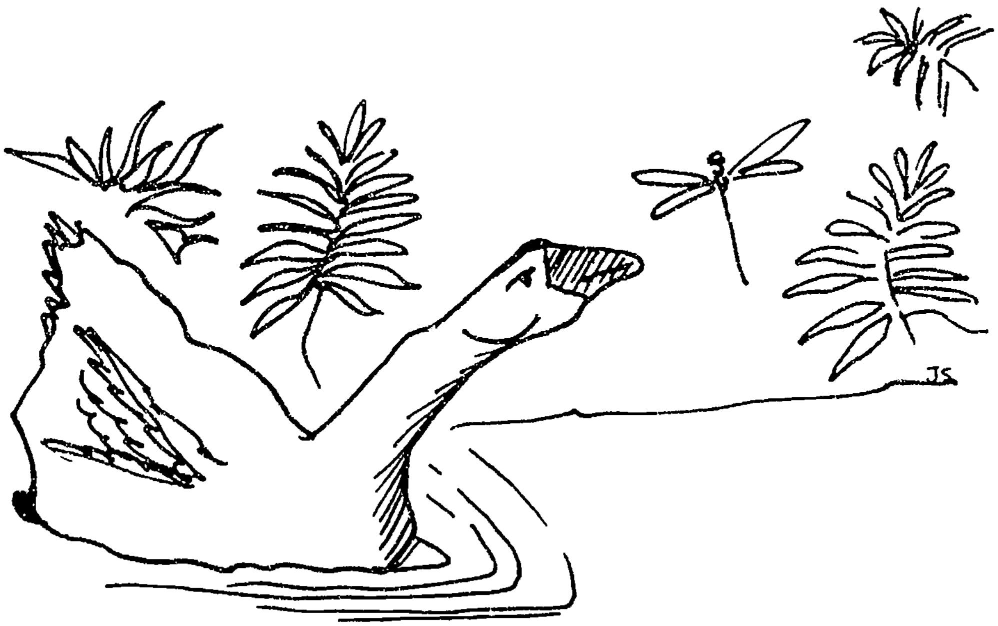
Inland wetlands are found throughout the interior of the country. They are most common on floodplains, along rivers and streams, in isolated depressions surrounded by dry land, and along the margins of lakes and ponds. Certain inland wetlands are characteristic of particular regions and influenced by the climate and landforms of the area. The five major wetland types include:

1. *Marine Wetlands:* The marine wetland system usually consists of the open ocean and any associated or related coastline. This is primarily a deepwater habitat system. Any true marine wetlands are limited to intertidal areas, e.g., coral reefs, rocky shores, and beaches in saltwater environments.
2. *Estuarine Wetlands:* The estuarine wetland system includes coastal wetlands like salt marshes and mangrove swamps, brackish (somewhat salty water) tidal marshes, deep water bays, coastal sounds, and intertidal flats. Salt marshes and brackish tidal marshes are influenced by the ebbs and flows of tides and by periodic flooding.

   These types of wetlands are found along the eastern (Atlantic) coast of the United States from Maine to Florida, the Gulf Coast from Florida to Louisiana and Texas, and in narrow bands along the western (Pacific) coast and the coastline of Alaska.
3. *Lacustrine Wetlands:* The lacustrine wetland system represents wetlands that are associated with standing bodies of fairly deep water like lakes, deep ponds and reservoirs.
4. *Riverine Wetlands:* Riverine wetlands are associated with freshwater rivers, streams, and

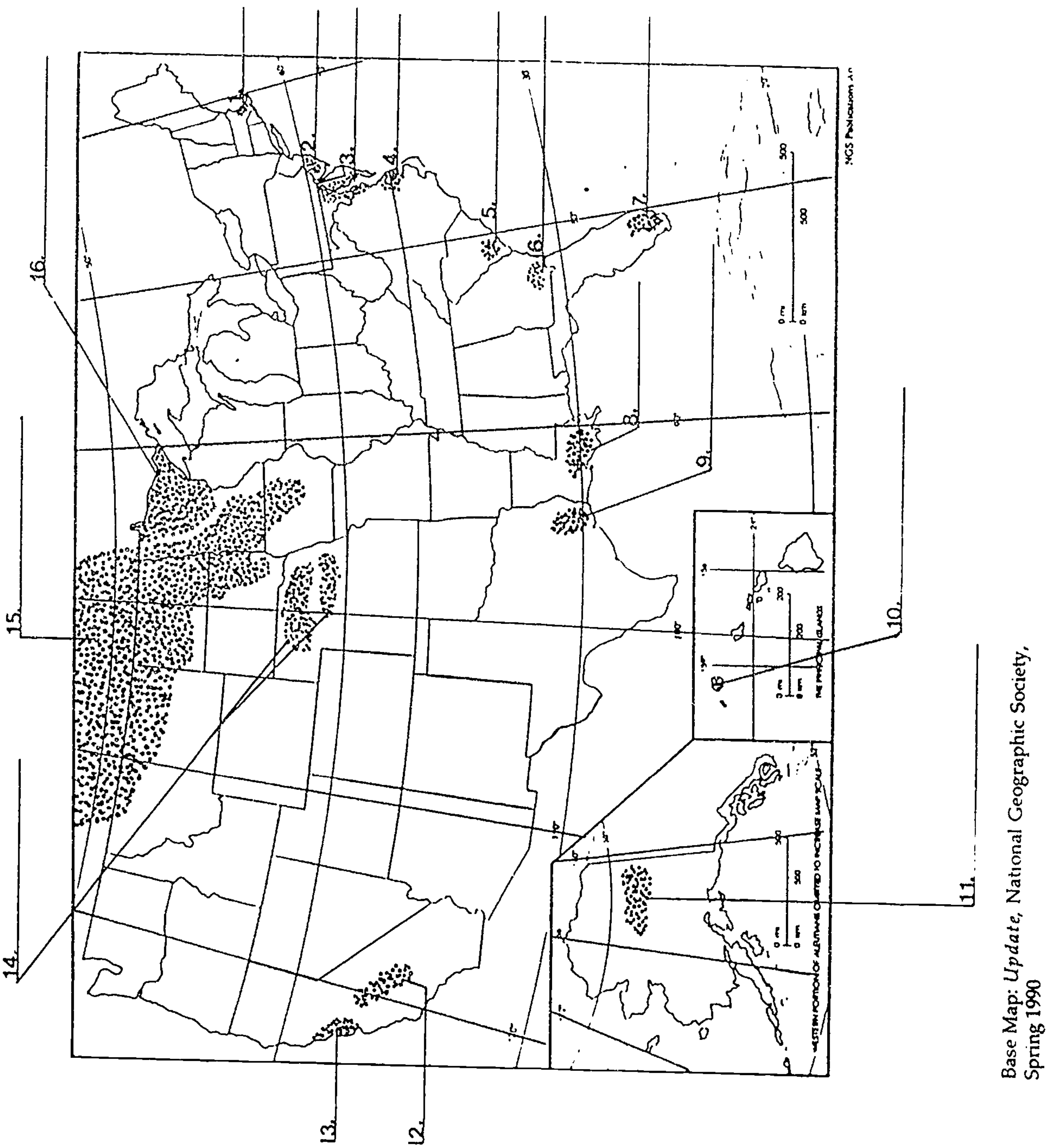
creeks. These riverine or riparian wetlands include marshes, bottomland hardwood swamps, and major floodplain wetlands. These wetlands have high species diversity, species density, and biological productivity. Many of these particular wetlands are subject to seasonal deposition of soil or periodic flooding. They are usually connected to upstream and downstream ecosystems, and because of the periodic flooding and deposition of silt and organic matter, these wetlands often accumulate rich alluvial (sediment deposited by flowing water, as in a riverbed, floodplain, or delta) soils.

5. *Palustrine Wetlands:* Palustrine (from the Latin *palus*, meaning marsh) wetland systems are inland freshwater wetlands that constitute the vast majority of our country's marshes, swamps, and bogs.



MAJOR WETLAND TYPES IN THE UNITED STATES: A MAPPING ACTIVITY

Figure 24: The United States: Major Wetlands



Base Map: *Update*, National Geographic Society, Spring 1990

Clues: Investigate each of the clues about major wetland types to find out where they are located in the United States and identify each type of wetland. You will not use every wetland type described on the previous pages although you may use some more than once.

Answer List: Match the clues with the names of the wetland areas listed below and their location on a map of the United States.

Alakai	Yukon Flats
Boston	Pine Barrens
Nebraska	Atchafalaya
Minnesota	Great Dismal Swamp
Central Valley	Chesapeake Bay
Okefenokee	Four Holes Swamp
Everglades	San Francisco Bay
Prairie Pothole Region	Big Thicket

Answers: 1—Boston(D); 2—Pine Barrens(E); 3—Chesapeake Bay(O); 4—Great Dismal Swamp(I); 5—Four Holes Swamp(G); 6—Okefenokee(J); 7—Everglades(M); 8—Atchafalaya(B); 9—Big Thicket(P); 10—Alakai(L); 11—Yukon Flats(C); 12—Central Valley(K); 13—San Francisco Bay(F); 14—Nebraska(A); 15—Prairie Pothole(H); 16—Minnesota(N)

Map Clues:

A. This wetland is located in the Platte River floodplain in the Central Plains of the country. These wetland areas provide nesting, breeding, and resting sites for migratory birds.

B. This riverine wetland is part of the Mississippi River drainage basin. It is the third largest continuous wetland of its type in the United States. It supports one-fourth of the nation's bottomland forests and is one of the most threatened wetland regions because much of the area is being converted for agricultural use. This is bayou country, home of the Cajun people.

C. These wetlands are associated with a major river in the state. They lie in the tundra region of the United States. This region still contains 170 million acres (69 million ha) of wetlands, the most in the state. They are still considered the most pristine in the United States.

D. Part of this New England city is build on a wetland site along the Charles River. The wetlands were filled in during the 1800s for development.

E. Cranberries are harvested from the swamp areas of this wetland. Large producers of cranberries are also Massachusetts, Wisconsin, Oregon, and Washington — all cool, moist regions. This wetland area is located in a coastal state along the eastern coast of the country.

F. This coastal city is located on the largest estuary on the west coast. It is on a critical flyway for migratory birds coming from Alaska and Canada. Open water, fresh and salt water marshes, mud flats, and salt evaporator ponds still offer an important refuge even though 90 percent of the wetland acres have been destroyed.

G. This swamp wetland is located in one of the southern states of the country. It is named for the four large lakes in it. The largest remaining old growth stand of bald cypress and tupelo trees is found here. Some are as old as 1,000 years. During the American Revolution, General Francis Marion got his nickname "Swamp Fox" because he hid in these swamps.

H. This extensive wetland region lies in several U.S. states and Canadian provinces. Most of the wetlands are millions of depressions in the landscape formed by glaciers. They support 50-80 percent of North America's wild duck population.

I. George Washington partly owned this swamp area in his home state. His efforts failed to drain the swamp for agriculture in the mid-1700s.

J. This marshy prairie consists of floating islands of peat. The Seminole Indians called this wetland trembling earth because it may or may not support body weight when walked on.

K. Historically, many of these wildlife refuges received a seasonal supply of water when mountain rivers, swollen by snowmelt, flooded the valley floor. Today irrigated farms and growing cities use such a huge amount of water that the refuges receive their water when only there is a surplus (none has been available for seven years because of drought).

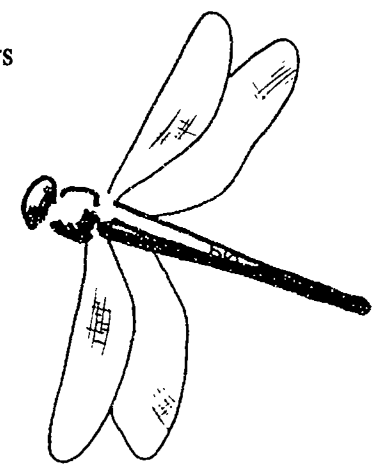
L. The swamp in the clouds is located inside a volcanic crater. This is a region of heavy rainfall and home to exotic species of birds.

M. Part of this southern wetland is a national park. The extensive cover of sawgrass has been nicknamed the "river of grass." The wetland is a freshwater swamp to the west and extends to the saltwater coast to the south where mangrove swamps are found.

N. Sphagnum mosses are the dominant types of vegetation found in this midwestern state. Glaciation has gouged out many lakes giving the state the nickname "land of the 10,000 lakes." Cranberries and wild rice are specialty crops raised in parts of this region.

O. This wetland region is the largest estuary in the United States. The Susquehanna River supplies 50 percent of the freshwater that flows into this body of water.

P. Thickets of oak and red bay trees provide shelters for wild pigs, black bears, bobcats, and many other species of wildlife. These huge trees are found in the wetland wilderness of the southeastern region of the Lone Star State.



PART 3: Wetland Losses—Wetlands: Lost and Found

INTRODUCTION

By the 1780s, in what today is the United States (including Alaska and Hawaii), an estimated 392 million acres (159 million ha) was in wetlands. Because of more than 200 years of wetland conversion, the country has experienced a 53 percent loss of the original acreage. Only an estimated 274 million acres (111 million ha) remain.

Only recently have we begun to recognize the values of wetlands and the benefits they provide to the environment. The growth and distribution of population and agricultural development greatly changed land use patterns that affect wetlands. As wetland resources diminish, the benefits they once provided no longer exist. Despite increased efforts to conserve wetlands through state and federal legislation, hundreds of thousands of acres continue to be drained annually. Their destruction or abuse can have devastating effects on wildlife, humans, and overall environmental quality.

Given the diversity of wetland types and their value as unique natural resources the crucial question remains: Is the country able to withstand continued losses of wetland acreage?

Purpose: To illustrate and evaluate the effects of wetland loss in the United States since colonial times, students will create two maps, one for estimated wetland area circa 1780s and one for the 1980s.

Suggested Grade Level: 7-12

Time: two or three class periods.

Themes or Key Ideas: location and relationships within places, humans and environments.

Concepts: total surface area (acres or hectares), percentage of surface area

Objectives: At the completion of the unit, students will be able to:

- Knowledge:
  - ☐ Learn how to plot data on maps to use as a tool for analyzing wetland distribution.
  - ☐ Compare the maps and make inferences about the status and trends in wetland loss in the United States between 1780 and 1980.
  - ☐ Make inferences about the distribution and changes in wetland acreage based on landforms and land-use patterns.
- Skills:
  - ☐ Read the table of data and understand the differences in terminology, total surface area, and percentage of surface area.
  - ☐ Map data for wetland distribution in the United States for both 1780 and 1980.
  - ☐ Use thematic maps and atlases to analyze the probable causes and patterns for losses shown on the maps.
- Attitudes and Values:
  - ☐ Understand the magnitude of wetland loss in the last 200 years of our history.
  - ☐ Appreciate the need to slow down and protect the destruction of wetlands.

Materials:

1. Table 1: Wetland Losses in the United States 1780s to 1980s.
2. Two outline maps of the United States (fig. 25).
3. Colored pencils: blue, green, orange, yellow, and red.
4. Question sheet: Wetland Losses: Status and Trends in the United States
5. Thematic maps of the United States: climate, physical, population, and land-use.

Procedure:

1. Give each student 2 outline maps of the United States (fig.25).
2. Entitle one map "Wetland Acreage Circa 1780s" and the other map "Wetland Acreage Circa 1980s."
3. Using Table 1: Wetland Losses in the United States and the appropriate columns of data, create two maps using the figures for estimated wetland acreage for each period of time. Decide ahead of time how the class will divide the numbers of acres (or hectares) into categories.
4. Use the following distribution of acreages (or in appropriate hectares) and colors as a key to color each state:

0-999,000	— Blue
1,000,000-3,999,000	— Green
4,000,000-10,000,000	— Yellow
11,000,000-16,999,000	— Orange
17,000,000 and over	— Red

Example: Pennsylvania had 1,127,000 acres (456,435 ha) in 1780 so you will color it green on the map.

5. Draw, label, and color a key on each map.
6. When the 2 maps are completed have students compare them. Answer and discuss the questions about the maps (see attached question sheet). Use both the maps and the data sheet to answer the questions.
7. Compare the 1980 map to the other thematic maps of the United States. Have students make inferences about why extensive losses because of practices such as urbanization or extensive farming practices. Summarize the status and trends of wetland losses since the 1780s.
8. Compare the 1780 map to a physical map of the United States and make inferences as to why few amounts of wetland acreage or an abundance of wetlands acreage exist in different regions of the country.

Reference

Dahl, T. E. 1980. *Wetland Losses in the United States 1780s to 1980s*. Washington, D. C : United States Department of the Interior, Fish and Wildlife Service.

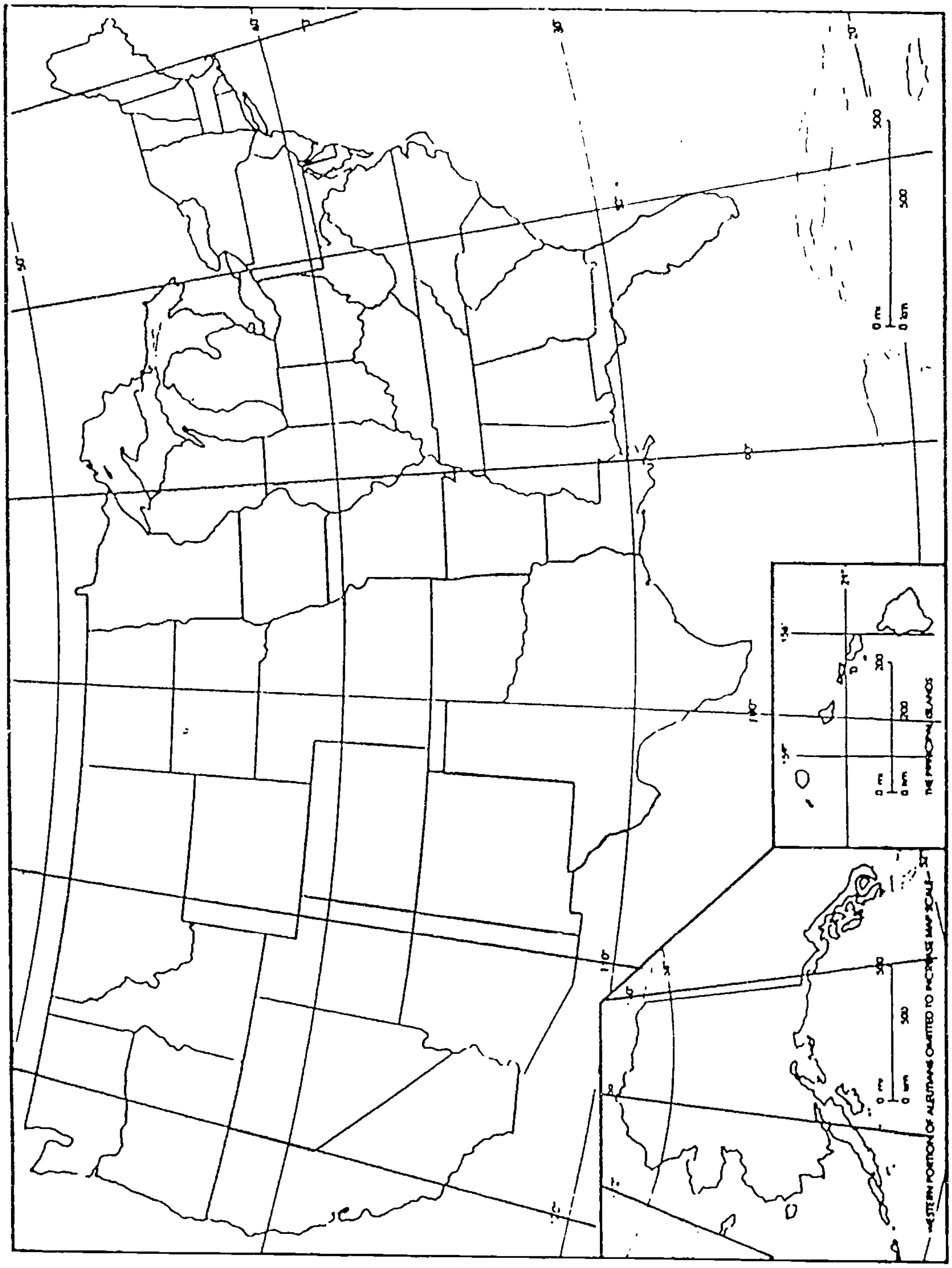
TABLE 1: WETLAND LOSSES IN THE UNITED STATES 1780'S TO 1980'S

	SURFACE AREA (ACRES)[1]			WETLANDS						
STATE	LAND	WATER	TOTAL	ESTIMATES OF ORIGINAL WETLANDS CIRCA 1780'S	SOURCE	% OF SURFACE AREA	ESTIMATES OF EXISTING WETLANDS CIRCA 1980'S	SOURCE	% OF SURFACE AREA	% OF WETLANDS LOST
AL	32,544,640	485,120	33,029,760	7,567,600	5	22.9%	3,783,800	5	11.5%	-50%
AZ	72,680,320	221,440	72,901,760	931,000	9	1.3%	600,000	10	0.8%	-36%
AR	33,392,000	594,560	33,986,560	9,848,600	11	29.0%	2,763,600	12	8.1%	-72%
CA	100,183,680	1,379,840	101,563,520	5,000,000	13, 14	4.9%	454,000	15, 16	0.4%	-91%
CO	66,428,800	289,920	66,718,720	2,000,000	17	3.0%	1,000,000	18	1.5%	-50%
CT	3,116,800	88,960	3,205,760	670,000	9	20.9%	172,500	19	5.4%	-74%
DE	1,268,480	48,000	1,316,480	479,785	20	36.4%	223,000	20	16.9%	-54%
FL	34,647,040	2,831,360	37,478,400	20,325,013	21, 22, 23	54.2%	11,038,300	24	29.5%	-46%
GA	37,246,080	434,560	37,680,640	6,843,200	11	18.2%	5,298,200	25	14.1%	-23%
ID	52,906,880	563,200	53,470,080	877,000	9	1.6%	385,700	10	0.7%	-56%
IL	35,761,280	334,720	36,096,000	8,212,000	27	22.8%	1,254,500	28	3.5%	-85%
IN	23,160,960	65,280	23,226,240	5,600,000	29	24.1%	750,633	30	3.2%	-87%
IA	35,867,520	158,080	36,025,600	4,000,000	31, 32	11.1%	421,900	31, 33	1.2%	-89%
KS	52,515,840	133,120	52,648,960	841,000	9	1.6%	435,400	10	0.8%	-48%
KY	25,504,640	348,160	25,852,800	1,566,000	34	6.1%	300,000	35	1.2%	-81%
LA	28,899,200	2,155,520	31,054,720	16,194,500	11	52.1%	8,784,200	36	28.3%	-46%
ME	19,797,120	1,460,480	21,257,600	6,460,000	37	30.4%	5,199,200	38	24.5%	-20%
MD	6,330,240	439,040	6,769,280	1,650,000	11	24.4%	440,000	39	6.5%	-73%
MA	5,013,120	271,360	5,284,480	818,000	37	15.5%	588,486	19	11.1%	-28%
MI	36,363,520	894,720	37,258,240	11,200,000	40	30.1%	5,583,400	10	15.0%	-50%
MN	50,744,960	3,058,560	53,803,520	15,070,000	11	28.0%	8,700,000	41	16.2%	-42%
MS	30,309,120	229,120	30,538,240	9,872,000	42	32.3%	4,067,000	12	13.3%	-59%
MO	44,189,440	409,600	44,599,040	4,844,000	11, 43	10.9%	643,000	44	1.4%	-87%
MT	93,185,920	982,400	94,168,320	1,147,000	9	1.2%	840,300	10	0.9%	-27%
NE	48,974,080	451,200	49,425,280	2,910,500	11	5.9%	1,905,500	10	3.9%	-35%
NV	70,328,960	416,640	70,745,600	487,350	45	0.7%	236,350	46	0.3%	-52%
NH	5,781,120	173,440	5,954,560	220,000	9	3.7%	200,000	47	3.4%	-9%
NJ	4,820,480	194,560	5,015,040	1,500,000	10	29.9%	915,960	48	18.3%	-39%
NM	77,724,800	141,440	77,866,240	720,000	9	0.9%	481,900	10	0.6%	-33%
NY	30,636,160	1,092,480	31,728,640	2,562,000	9, 49	8.1%	1,025,000	49	3.2%	-60%
NC	31,283,200	2,371,840	33,655,040	11,089,500	42	33.0%	5,689,500	12	16.9%	-49%
ND	44,339,200	886,400	45,225,600	4,927,500	50	10.9%	2,490,000	51	5.5%	-49%
OH	26,251,520	130,560	26,382,080	5,000,000	52	19.0%	482,800	10, 52	1.8%	-90%
OK	44,149,760	598,400	44,748,160	2,842,600	53, 54, 55	6.4%	949,700	53, 54, 55	2.1%	-67%
OR	61,573,760	494,080	62,067,840	2,262,000	9	3.6%	1,393,900	10	2.2%	-38%
PA	28,816,000	197,120	29,013,120	1,127,000	56	3.9%	499,014	39, 56	1.7%	-56%
RI	671,360	105,600	776,960	102,690	57	13.2%	65,154	58	8.4%	-37%
SC	19,379,200	496,000	19,875,200	6,414,000	42	32.3%	4,659,000	12	23.4%	-27%
SD	48,611,840	698,240	49,310,080	2,735,100	59	5.5%	1,780,000	51	3.6%	-35%
TN	26,474,240	561,920	27,036,160	1,937,000	42	7.2%	787,000	12	2.9%	-59%
TX	168,300,800	2,796,160	171,096,960	15,999,700	60	9.4%	7,612,412	61	4.4%	-52%
UT	52,723,840	1,622,400	54,346,240	802,000	62	1.5%	558,000	63, 64	1.0%	-30%
VT	5,935,360	214,400	6,149,760	341,000	65	5.5%	220,000	19	3.6%	-35%
VA	25,498,240	624,640	26,122,880	1,849,000	10	7.1%	1,074,613	39, 66	4.1%	-42%
WA	42,664,320	978,560	43,642,880	1,350,000	67	3.1%	938,000	67	2.1%	-31%
WV	15,413,760	62,080	15,475,840	134,000	68	0.9%	102,000	39	0.7%	-24%
WI	34,856,960	1,081,600	35,938,560	9,800,000	69	27.3%	5,331,392	70	14.8%	-46%
WY	62,259,840	405,120	62,664,960	2,000,000	10	3.2%	1,250,000	71	2.0%	-38%
SUBTOTAL (CONTERMINOUS U.S.)	1,899,526,400	34,672,000	1,934,198,400	221,129,638		11%	104,374,314			53%
ALASKA	362,516,480	12,787,200	375,303,680	170,200,000	6	45.3%	170,000,000	7, 8	45.3%	0.1%
HAWAII	4,112,000	3,200	4,115,200	58,800	26	1.4%	51,800	16, 26	1.3%	12%
TOTAL U.S.	2,266,154,880	47,462,400	2,313,617,280	391,388,338			274,426,114		11.9%	30%

NOTE: Surface area – There are some discrepancies between the total surface area of states. These differences are probably due to shifting river channels forming state borders. The area given is that presented by the U.S. Geological Survey, National Atlas of the United States, 1970.

Wetland distribution and changes vary dramatically within states dependent on both geographical and/or land use patterns.

Figure 25: The United States



Base Map: *Update*, National Geographic Society, Spring 1990

Wetland Losses: Status and Trends

QUESTION SHEET

Answer the following questions by using the two maps you colored comparing losses in wetland acreage between 1780 and 1980 in theUnited States.

1780 Map

1. Which two states on the 1780 map show the greatest amount of wetland acreage?
2. What are some possible reasons why the states in #1 have a high number?
3. In which two general regions of the country do we find the least amount of wetland acreage?
4. Which part of the country, in general, has the most wetland acreage?
5. Compare the 1780 map to a rainfall or climate map. Is there a relationship between how the wetlands are distributed and the climate for those regions?
6. Where does your state rank on the 1780 map?
7. Does any state have no wetland acreage?
8. Which state has the greatest amount of wetland acreage?

1980 Map

9. Which state has the greatest amount of wetland acreage?
10. Is this the same or a different state you answered for #9 than in 1780?
11. Why hasn't this state (#9) probably changed as much as others?
12. Which state has lost the greatest number of acres by 1980?
13. Why do you think the state you answered for number 12 has lost so much acreage?
14. How many states have lost enough acreage to change their categories on the map?
15. Did the status of your state change?
16. What are some of the things occurring in your state to threaten wetlands?

Table

17. Which of the 50 states has lost the greatest amount of original wetland acreage?
18. Which of the 50 states has lost the smallest wetland acreage since 1780?
19. List the 22 states that have lost 50 percent or more of their wetlands since 1780.
20. Has any state not lost any wetland acreage since 1780?

Summary Questions

21. Between the 1950s and the mid-1970s alone, about 11 million acres (4,445,000 ha) of marshes and swamps were destroyed in the United States. Summarize your reasons for such major losses.
22. What is the pattern of relationship between the percentage (or total acreage) of wetland loss and the location of the state or region in which it has occurred?
23. What if the loss of wetlands went unchecked for another 200 years. What regions of the country do you think would suffer the greatest losses? Why?

C. FUNDAMENTAL THEMES, WETLANDS PERCEPTIONS AND FUNCTIONS, CARTOGRAM PREPARATION

Brother Howard Metz

INTRODUCTION

This lesson will emphasize wetlands and how students can study them according to the five fundamental themes in geography. Methods include: group and class discussion, student-designed definitions, circle diagrams, and developing the bases for a cartogram. Skill development includes asking geographic questions and presenting geographic information in a variety of ways.

Grade Level: high school or grades 8-10.

Time Required: two or three class periods.

Theme or Key Ideas: location, place, movement, human-environment interaction, and region

Concepts: changing perceptions, function, value

Objectives: At the completion of this unit, students will be able to :

- Knowledge:
  - Identify elements in a definition of wetlands.
  - Understand how to use circle diagrams for presenting geographic information.
  - Understand the difference between function and value.
- Skills:
  - Write and evaluate their definitions for wetlands.
  - Complete a circle diagram on the five fundamental themes.
  - Complete circle diagrams on changes in perceptions and the concepts of function and value.
  - Design a cartogram.
  - As an extension, design a crossword puzzle.
- Attitudes and Values:
  - Understand human perceptions of places change with time.
  - Learn to appreciate wetlands.

Materials:

- Loose-leaf paper, pens, information from this book, coloring pencils, list of areas of the conterminous 48 states in square miles (or kilometers).

Suggested Materials:

- VHS Tape: National Geographic Society. 1993. *The Power of Water*, Washington, D.C.: Author. 1-800-358-2728 or Fax 1-301-921-1575. Length 59 minutes.

- Articles:

  Kusler, J. A., et al. 1994. *Water: The Power, Promise, and Turmoil of North America's Fresh Water*. Washington, D. C.: The National Geographic Society, 1994.

  Joint Committee on Geographic Education. 1984. *Guidelines for Geographic Education: Elementary and Secondary Schools*. Macomb, Ill. and Washington, D. C.: National Council for Geographic Education and Association of American Geographers.

  Postel, Sandra. 1992. *Last Oasis*. New York: Worldwatch Institute.

ACTIVITY ONE:

1. To introduce the lesson, divide the class into small groups of four students. Have paper and pencil available for each group. Ask one student to serve as the recorder. Tell the students that everyone has an idea about wetlands. Ask each group to write its definition for wetlands.
2. Ask a student in each group to read the group's definition to the class. Identify some of the common elements among the groups' definitions.
3. Provide each group with a copy of the definition for wetlands from *Wetlands: Science, Politics, and Geographic Relationships*. (See Chapter 2 for Definitions of Wetlands). Ask each group to compare its definition to that in the book. Discuss the differences.
4. Take the students a step further by discussing the three fundamental characteristics of all wetland ecosystems: hydrology, hydric soils, and hydrophytes.
5. Explain to the students that despite recognition of these three common characteristics, no consensus remains on a single definition because of the numerous reasons cited in the book.

   □ Note: At this point, the lesson presumes that the students have been introduced to the five fundamental themes of geography in previous work.
6. Tell the students we can use overlapping circles to show the relationship between wetlands and the five fundamental themes of geography.
7. Provide each student with a copy of the overlapping circles (fig. 27). Point out to the students that the theme of location was placed in the middle because location is the starting point for all geographical investigations and that each of the themes must include the element of location as its starting point.
8. Lead a discussion on how to complete the circle diagrams with geographical questions and information. You may want to divide the class into groups for this section.
9. If the class does not complete the circles by the end of the class period, ask the students (or groups) to complete them for homework and bring them to class the following day.

ACTIVITY TWO:

1. Recall the previous day's work: finish any discussion on the five fundamental themes.
2. Ask the students for their ideas about the use of the word perception. Tell them that in some ways perception encompasses the feelings we bring to our investigations about persons, places, or things. Our experiences, values, and senses help us to make these decisions.

Figure 26: Using the Five Fundamental Themes to Teach about Wetlands

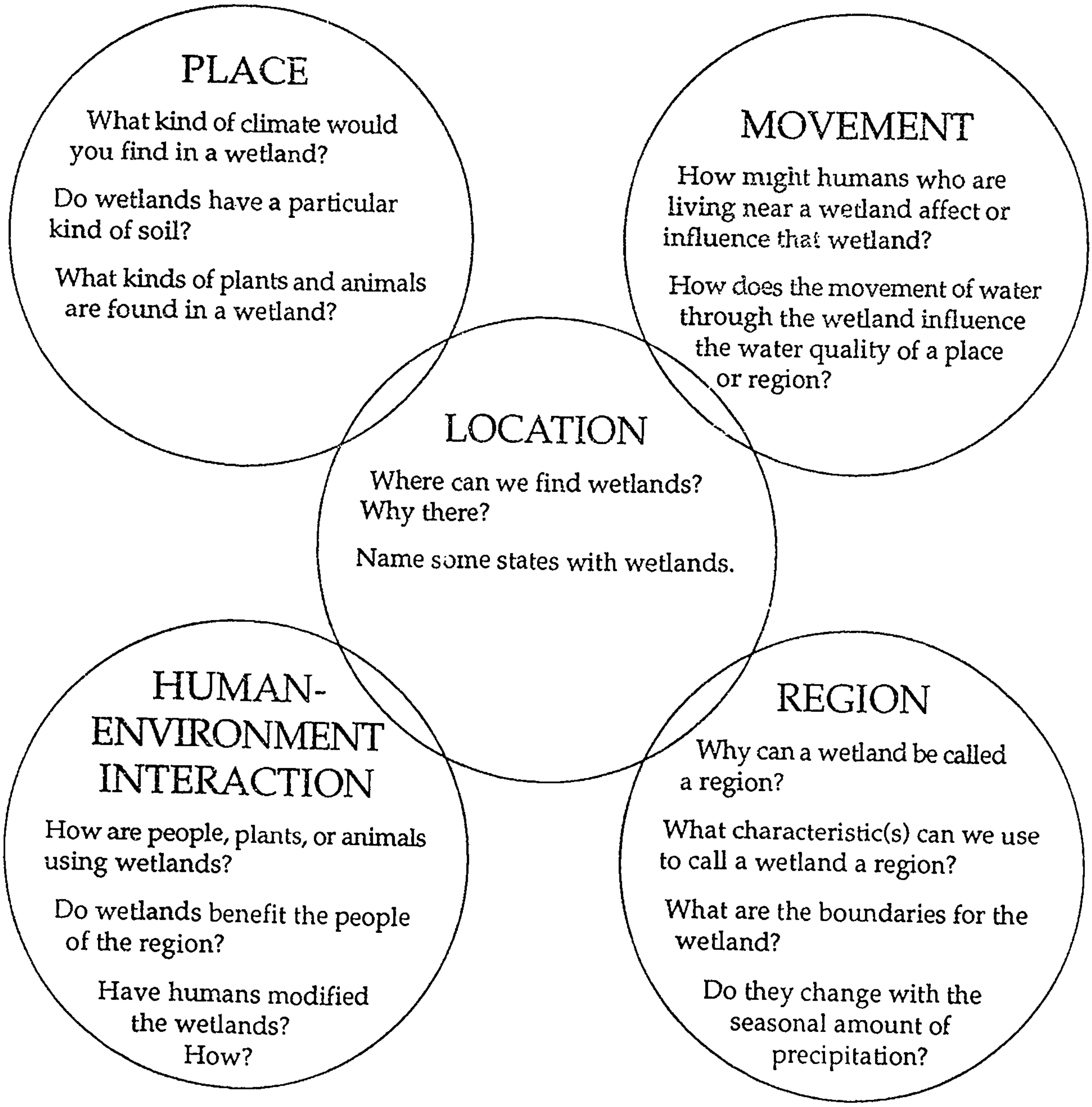
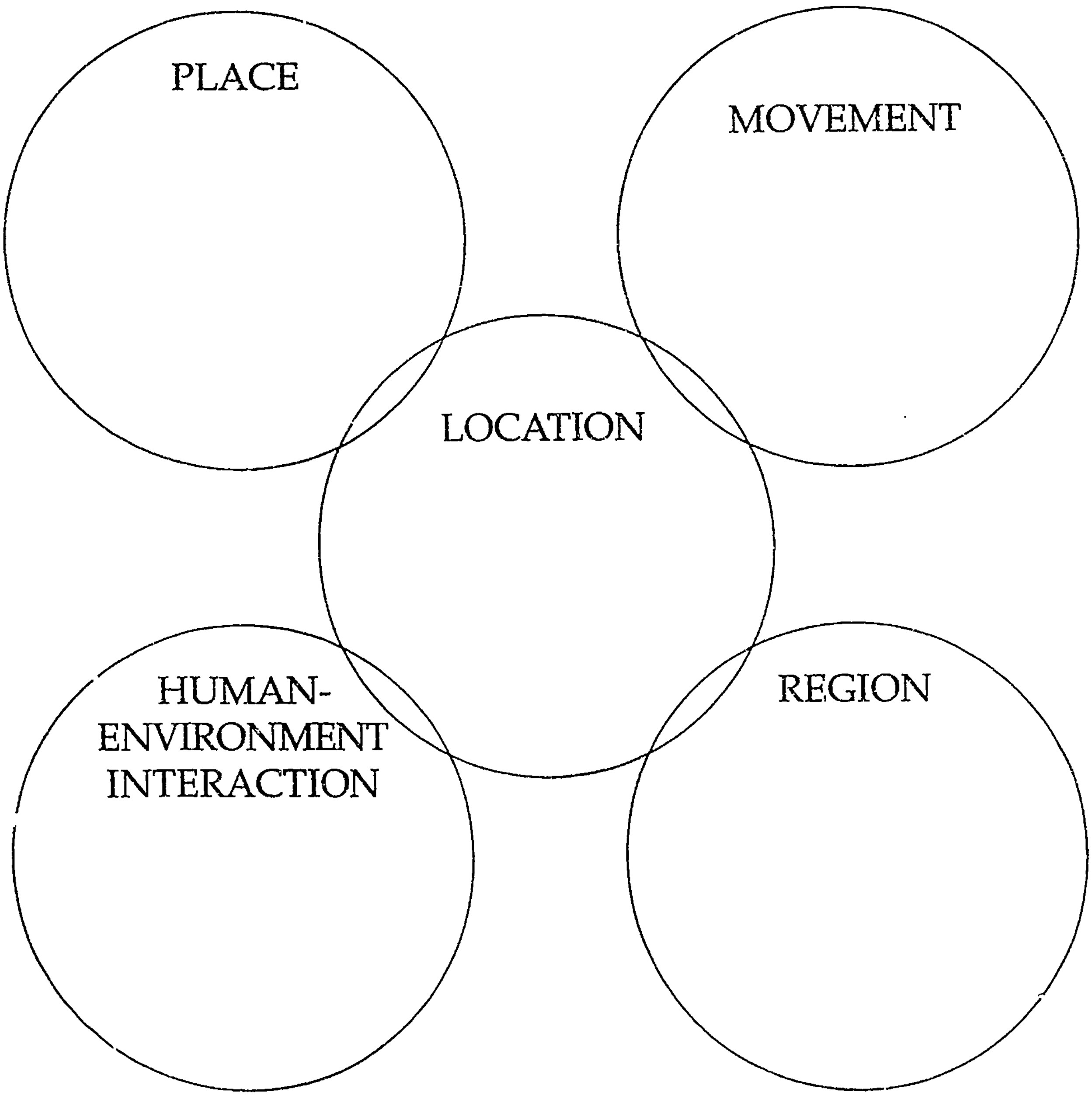


Figure 27: Using the Five Fundamental Themes to Teach about Wetlands



3. Discuss with the students some ideas about why humans' perceptions of wetlands have changed over the years (see Benhart and Margin 1994, Chapter 1 on changing attitudes about wetlands and fig. 28). Give each student a copy of the paper with the outline of a table on it (fig. 29). Because the two sides of the table are on opposite sides of the page, we have two ways or schools of thought on wetlands. Notice the time periods differ. Guide the students through the ways people viewed wetlands in the past and how people perceive them today. Fill in each circle with information.
4. Introduce the term, *areal cartogram*, to the students.[3] Discuss with them that an areal cartogram is a kind of map where one of the features of a country or a political unit determines its size. A cartogram might be based on population, Gross National Product, or some other characteristic (fig. 30). Give each student a copy of the graph paper. Review with them the size of an acre or hectare of land. Assign a value to each square on the graph. One square will equal 1 million acres or 405 thousand hectares. Have the students use coloring pencils and have them shade in 221 (million acres) squares or 89.5 (million hectares) squares (see Table 1, Learning Activity 2: Wetland Losses in the U.S. 1780s to 1980s). Next, have them shade in the amount of squares needed to show the amount of destroyed wetlands (117.7 million acres or 47.7 million hectares). They should shade in 117.7 million squares (or 47.7 squares if each square represents 1 million hectares). Note the significant difference in the two graphs. Answer the question at the bottom of the graph. (Answer: By having students look at a list of the states and their areas in square miles (or square km), the United States lost wetlands approximately the size of Texas and South Dakota combined).
5. Introduce the students to the concepts of function and value. (See Benhart and Margin 1994, Chapter 3, and fig. 32). Give each student a copy of the overlapping circles (fig. 33). Classify information from the book inside each circle. Point out to the students that the overlapping section of the circles (designated by diagonal lines) represents wetlands.
6. Assignment: Have each student write a one- or two-page essay about wetlands. Ask them to integrate information from their definitions, the circle diagrams, and the graphs into their essays.

EXTENSION ACTIVITIES:

1. Divide the class into groups. Assign each group a different state. Have the students investigate the information available on wetlands for their state.
2. Ask each group to give an oral report to the class.
3. Select twenty different words from the Glossary. Have each student construct a crossword puzzle. Ask students to have ten words going across and ten going down.
4. In a future class period, have the students work in groups and complete the puzzles. Have the original designers of the puzzles check the answers for the group.

[3] In this exercise students will not prepare a true cartogram but will simply prepare the basis for one. For example, after they have completed the charts, they might want to experiment with drawing two outline maps of the United States using separate sheets of graph paper. The first areal cartogram would be based on the data on the chart from 1780, the second after losing 117.7 million acres (47.7 million ha) of wetlands.

Figure 28: How Has Human Perception about Wetlands Changed?

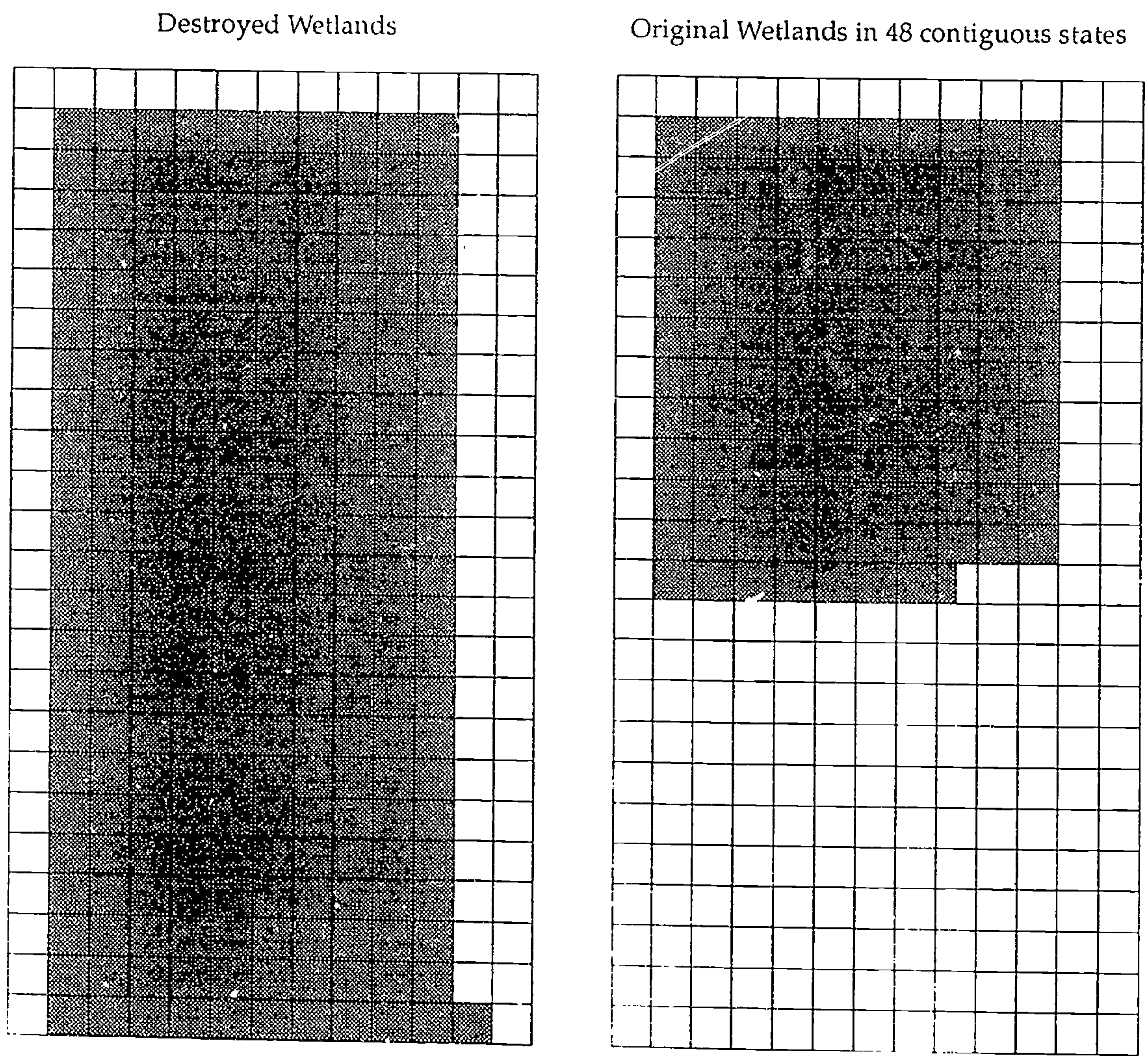
1700s, 1800s, 1900s — Early 1970s	Early 1970s — Present Time
Insect-infested wasteland	Wetlands are of value to the global environment
Land with no practical use or value	Wetlands have economic value to humans
Unhealthy places	Under law, the federal government protects and preserves wetlands
Humans must subdue this useless and unhealthy place. The United States government promoted this cause.	

Figure 29: How Has Human Perception about Wetlands Changed?
(Outline Table):

ACTIVITY: Developing the Basis for a Cartogram of Wetlands

An acre of land is 43,560 square feet. One hectare equals 2.4 acres. If we use the image of a football field, the approximate size of an acre of land would be from one goal line to the ten yard line on the other side (approximately 43,200 square feet).

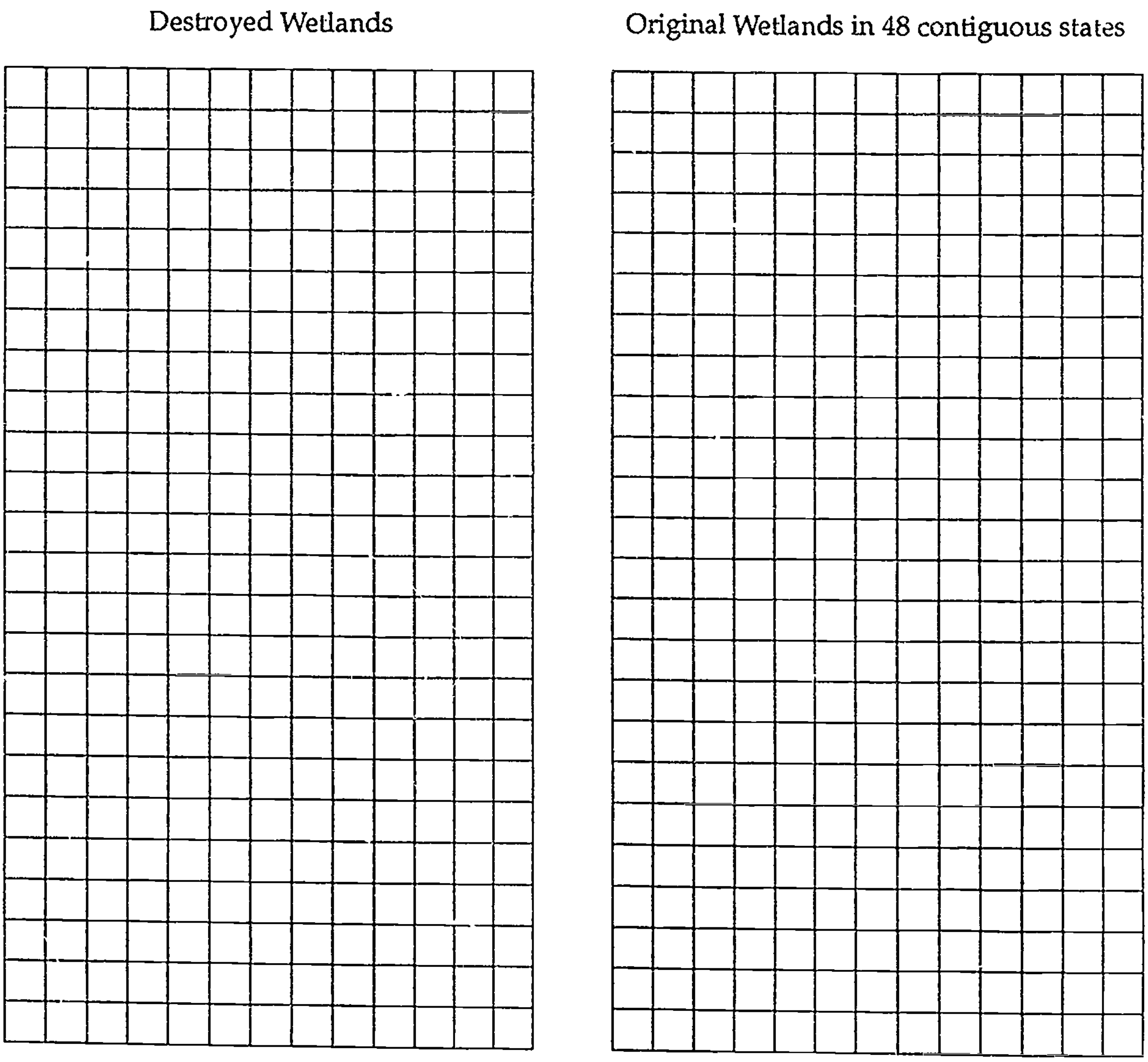
Figure 30: Basis for Cartogram of Wetlands
1 square represents 1 million acres (405 thousand hectares)



A square mile contains 640 acres or 259 hectares. Look at a list of states and their areas in square miles. Multiply a state's square miles by 640 (divide this figure by 2.47 to find hectares). If you compute this for Texas and South Dakota, what relationship exists between their total acres or hectares and the original amount of wetlands?

Note: An acre of land is 43,560 square feet. One hectare equals 2.47 acres. If we use the image of a football field, the approximate size of an acre of land would be from one goal line to the ten yard line on the other size (approximately 43,200 square feet).

Figure 31: Basis for Cartogram of Wetlands
1 square represents 1 million acres (405 thousand hectares)



A square mile contains 640 acres or 259 hectares. Look at a list of states and their areas in square miles. Multiply a state's square miles by 640 (divide this figure by 2.47 to find hectares). If you compute this for Texas and South Dakota, what relationship exists between their total acres or hectares and the original amount of wetlands?

Note: An acre of land is 43,560 square feet. One hectare equals 2.47 acres. If we use the image of a football field, the approximate size of an acre of land would be from one goal line to the ten yard line on the other size (approximately 43,200 square feet).

Figure 32: Function and Value Relationships of Wetlands

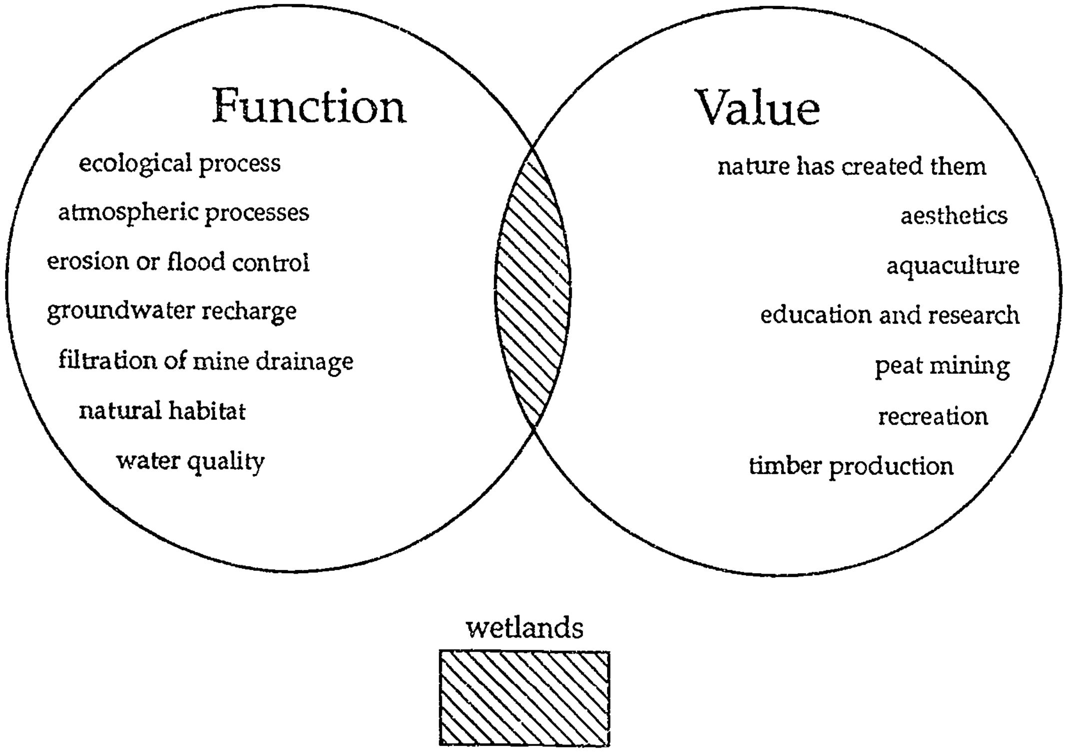
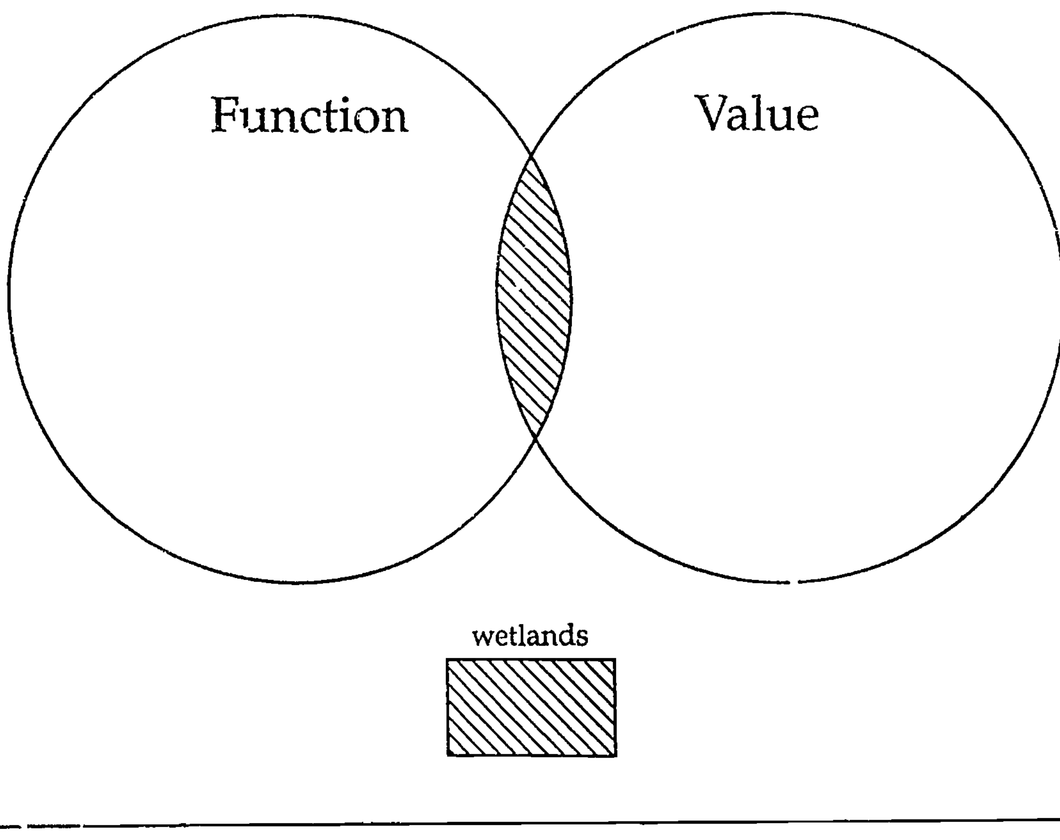


Figure 33: Function and Value Relationships of Wetlands



D. THE SCIENCE, POLITICS, AND GEOGRAPHIC RELATIONSHIPS OF WETLANDS

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SENIOR HIGH SCHOOL OR COLLEGE

INTRODUCTION:

This lesson will focus on wetlands science, politics, and geographic relationships. Several suggested methods include: using aerial photography, discussions, role playing, readings, oral and written communications. Skill development includes asking geographic questions and presenting geographic information.

Grade Level: university (can work at senior high school level)

Time Required: four to five class periods.

Themes or Key Ideas: location, place, human/environmental relationships, regions.

Concepts: wetlands, wetland functions, nonpoint pollution, marine, estuarine, riverine, lacustrine, palustrine, artificial wetland, introduced species.

Objectives: At the completion of this unit, students will be able to:

- Knowledge:
  - Identify several problems associated with wetlands.
  - Determine the severity of problems associated with wetlands.
  - Analyze materials.
  - Synthesize materials to develop solutions for problems.
  - Evaluate solutions and draw conclusions about their resolution.
- Skills:
  - Develop geographic questions by presenting issues to students.
  - Gather information and data from a variety of media and use them to describe trends.
  - Use aerial photos to gather data.
  - Use data from the aerial photos to describe trends.
  - Exercise deductive reasoning (identifying relevant questions; collect and assess appropriate evidence).
  - Present evidence in verbal and written form.
- Attitudes or Values:
  - Understand the inter-relatedness of ecosystems.
  - Understand the destruction of irreplaceable resources.
  - Appreciate perspectives of others.
  - Appreciate the value of teamwork.

Materials:

- VHS Tapes
- National Geographic Society. 1993. *The Power of Water*. Washington D.C.: Author. 1-800-358-2728 or Fax 1-301-921-1575 Length: 59 min.
- Articles

  Duram, Leslie A. 1995. (forthcoming) "Water Regulation Decisions in Central Kansas Affecting Cheyenne Bottoms Wetlands and Neighboring Farmers." *Great Plains Research* 5.

  Hill, Alan. 1990. "The Biochemistry of Small Headwater Wetlands." *The Canadian Geographer* 34:85-87.

  Mairson, Alan. 1994. "The Everglades: Dying for Help." *National Geographic* 185: 2-35.

  Mitchell, John G. 1993. "Our Disappearing Wetlands." *National Geographic* 184: 3-45.
- Aerial Photographs:

  The Soil Conservation Service is a source of aerial photography or perhaps the physical geography lab in your university has some you can use.

Suggested Resources:

Zimmerman, John L. 1990. *Cheyenne Bottoms, Wetland in Jeopardy*. Lawrence: University Press of Kansas.

Films for the Humanities and Sciences. *Wetlands and Pinelands*. Princeton, N. J.: Author. Order from: Films for the Humanities and Sciences. P.O. Box 2053, Princeton, NJ 08543-2053.

ACTIVITY ONE:

1. Have students keep wetlands journals or logs as part of the assignment. They must use a clean notebook devoted solely to this project. If they prefer to use word processing they should put the entries in a binder. They must date and title their entries. I find that journals are an excellent way for students to articulate and resolve those things they do not understand. (In my World Regional Geography and Geography of the United States and Canada classes, I expect students to write three geographic entries per week. In addition, they must demonstrate that they understand how an entry relates to the curriculum.)
2. Prior to the lesson on wetlands, place the Duram, Hill, Mairson, and Mitchell articles (see References above) on reserve in the library and assign either one or all as part of the reading assignment in the syllabus.
3. Have students define wetlands in their journals. Defining wetlands is a key issue in the politics of wetlands so it will take some research on their part to consolidate materials adequately to define the word and concept.
4. Show the film in class. You may wish to show only those portions you consider most relevant to the class. Have students respond to the film in their journals. Have them share their responses both to the articles and the film in class.
5. To promote the sharing process, ask questions about the content of the articles. For example, ask students about the locations of wetlands are found and why they are there. Also ask them

if wetlands destruction affects them personally, and if so how?

6. On the blackboard list the characteristics of wetlands. Define words students do not understand.
7. Instruct students to record on a map as many locations as they can where wetlands destruction is a problem.
8. Distribute a list of terms, from this booklet, students should be able to define for a later exam. Have them record the definitions in their journals.

ACTIVITY TWO:

1. Prior to the unit, acquire aerial photographs of an area that includes a wetland. Have copies available over a period of several years showing the identical area. The physical geography laboratory at your institution may have some available for your use. The Soil Conservation Service is also a good source of aerial photography.
2. Divide students into groups of three or four to examine the photographs.
3. Have students identify objects in the photographs, e.g., transportation routes, housing developments, or agricultural areas. See if students can find the wetlands in the photographs Do not assume that students have prior knowledge about aerial photographs. If not, be certain you assist them in the identification process. Have students examine the same area or region on all photographs comparing what they see from the past to the present.
4. Instruct the students to make notes in their journals about changes they discover in the wetlands over a period of time. Have students hypothesize why changes may have taken place.

ACTIVITY THREE:

1. Students will continue their wetlands investigation using professional journals. Have students look up four to six articles using the annotation form provided. One article should be about wetlands in countries other than the United States and Canada. Having students make annotations is excellent for them to acquire information and in addition to examining the professional literature. Students should record their annotations in the journals. A sample of the form I use follows.
2. Break class into groups of three or four students. Using their combined annotations and notes from journals, they will develop some hypothesis(es) regarding wetlands. Provide groups with a transparency and markers to record their hypothesis(es).
3. Instruct students that they are to discuss, as a group, how to solve the problem then write the solution(s) on the transparency.
4. Have one person from the group give an oral presentation of the hypothesis(es) and solution(s) to the class. They must defend their solution.
5. Instruct students to write an essay in their journals including the hypothesis(es) and solution(s). They must defend their solution(s).

Annotator: ______________________________

Volume number: ________ **pages:** ________ **month:** ________ **year:** ________

Title of article: ______________________________

Author: ______________________________

(Last name) *(First name)* *(Middle name)*

Annotations for Unit: ______________________________

Annotations for Wetlands: ______________________________

Question/Problem: ______________________________

Summary: (Does author answer questions or give solutions to the problem?) ______________________________

____

____

____

Critique (Agree, disagree, suspend judgment, defend with other readings, or own experiences):

____

____

____

ACTIVITY FOUR:

I have used the role play activity in regional classes and in an environmental issues class. It has helped students analyze and synthesize information that leads to a decision on the issue. I will also use the self-directed activity as the major project for a Resource Management class. This activity will help students assess how human environmental interactions may influence wetlands.

1. Use role play activity to help students appreciate the perspectives of other people.
2. Prepare index cards for the class and write one of the following persons or group on each card: governor, environmentalist, unemployed construction worker, wildlife service employee, agriculturalist or farmer, city commissioner, local citizen, or fisherman. You might prefer to include other individuals or groups.
3. Divide the class into groups equal to the number of index cards. Give each group one card.
4. Set the scene using a scenario such as the one provided. This scenario involves a river (although your region may have a wetland nearby that would have relevance for the students). If so, adapt the scenario accordingly. For example, Don Developer owns a development and construction business. He wants to buy a piece of property adjacent to a river near your community on which he would like to build a factory outlet mall. The targeted area presently provides habitat for migratory birds. This river also provides drinking water for your city. Your city planning or zoning commission is holding a public information meeting so that citizens and officials can express their concerns about the proposed development before granting permission for construction.

5. Instruct students to discuss the question and answer it from the perspective of the person or group on the card. Randomly call on groups to respond to the questions. After the first question has been discussed, have students pass the cards clockwise to another group. Students must now discuss the next question from the perspective of the person or group on the new card. Continue in this manner until they have discussed all the questions.

SUGGESTED QUESTIONS:

a. Should the planning or zoning commission allow development on fragile wetlands?
b. Should economics take precedence over ecology?
c. Should risks to ecosystems be avoided at the expense of development?
d. How can you reach a compromise between economics and ecology?
e. Should government intervene in wetland development and change? If so, what should be the nature of that intervention?
f. What kinds of problems could take place because of poor drainage?
g. Conclude the lesson by comparing and contrasting issues regarding wetlands with other water issues the group has studied. Instruct students to summarize the comparison in their journals.

If you have studied no other water-related issues, summarize the lessons by compiling a list on the chalkboard or a transparency of all wetlands issues investigated by the class and the proposed solutions. Direct students to summarize the issues and solutions in their journals.

EXTENDED ACTIVITY: Self-Directed Field Research

1. Ask students to work in groups of three or four. Each group will perform self-directed field research at a nearby wetland. Provide a list or ask students to investigate the locations of nearby wetlands and let the group select one to use as its research area. The group will decide when they will do their field research within the time allotted by the instructor.
2. Students should carry a topographic map or aerial photograph to the site of their research area. Many college libraries have topographic maps that students can check out for short periods.
3. Instruct students to answer the following questions:

   a. Is cropped agriculture near the wetland?

   b. Are livestock adjacent to or near the wetland?

   c. Is irrigation water diverted from or near the wetland?

   d. If cropped land is nearby, does the farmer use chemicals on it that would threaten the wetland from nonpoint pollution?

   e. If cropped land is nearby, does the farmer plow to the edge of the wetland or is there a buffer zone?

   f. What kind of crops are being raised near the wetland?

   g. Is suitable habitat available for bird nesting?

h. Does the wetland dry up during part of the year or is the ground saturated year round?

i. What kind of natural vegetation do you find?

j. Are development projects near or around the wetland?

k. What type of drainage patterns characterize the area? Use the topographical map to help you.

l. Make a sketch map of the wetland. Include areas that may be in danger of modification.

m. Students will write individual research papers describing, analyzing, synthesizing, and evaluating the data gathered.

Evaluation: Assessing the journals can serve as one evaluation and students can develop a master plan for wetland preservation, either locally, regionally, or nationally. If you include the field experience, also evaluate the research paper.

APPENDICES

A: Glossary of Wetlands Terms

acid - a term applied to water with a pH less than 5.5.*

alkaline - a term applied to water with a pH greater than 7.4.*

*A technical point should be noted. Strictly interpreted, to say that a solution has a high pH, means that it has a high power of hydrogen, making the solution acidic. In widespread usage, however, high pH is interpreted as meaning high in number, such as pH 10. A solution of pH 10 is alkaline, not acidic.

alluvial - of or pertaining to deposits of sand, silt, clay, formed by flowing water.

anaerobic - a condition in which molecular oxygen is absent (or effectively so) from the environment.

areal extent - the entire ground surface area of a place or region, whether graphically depicted on a map or at a physical location, that has some physical or conceptual uniqueness which sets it apart from surrounding areas, e.g., a forested area or an area defined by political boundaries.

aquatic bed wetland - a wetland class characterized by plant growth, at or below the water surface.

artificial wetland - a wetland created by purposeful human activity. Also known as artificial marshland, engineered wetland or marshland, and human-designed marshland or wetland.

baseline - a line, generally a road or some other evident feature, from which sampling transects extent into a site for which measurements are drawn.

biological diversity (biodiversity) - having a greater than average variety of life forms within a localized area, ecotone or ecosystem.

biologic zero - the temperature at which plant growth subsides and dormancy predominates, generally defined as 5 degrees Celsius (C) or 41 degrees Fahrenheit (F).

bog - a wetland characterized by a thick layer of peat and having no regular inlet or outlet of water; a shrub peatland; a moor.

botany - the branch of biology that investigates plant life.

brackish waters - waters that contain a salt content less than that of normal seawater, generally occurring where freshwaters and seawaters merge; slightly salty.

buffer - an area of uplands immediately adjacent to a wetland.

buttresses - the swollen or enlarged bases of trees developed in response to conditions of prolonged inundation.

chroma - the relative purity or saturation of a color; intensity of distinctive hue as related to grayness; one of three variables of color.

circumneutral - a term applied to water with a pH range of 5.5 to 7.4; neither highly acidic or highly alkaline.

criterion (criteria, pl.) - a standard or technical requirement. People generally make decisions on the basis of several criteria.

deepwater habitat - any open water area in which the mean water depth exceeds 6.6 feet at mean low water in nontidal and freshwater tidal areas, or is below extreme low water as spring tides in salt and brackish tidal areas, or the maximum depth of emerging vegetation, whichever is greater.

delimit - to fix or mark the limits of; demarcate.

delineation - the process of determining a wetland's physical boundaries.

dentification - the decomposition of exfoliated (fallen) leaves and other vegetative matter; the chemical breakdown of dead vegetation, mostly through bacterial and fungal activity.

dike - a human-designed barrier, the purpose of which is to obstruct the inflow of water that creates a land area from wetland.

disturbed area in wetland studies, refers to places where human activities or natural events have sufficiently altered indicators of one or more characteristics (vegetation, soil, or hydrology) and make it difficult to recognize whether the area can meet the wetland identification criteria.

drained - a condition in which artificial or natural means have removed ground or surface water.

draft line - an accumulation of water-carried debris along a contour or at the base of vegetation that provides direct evidence of prior flooding.

ecology - the branch of biology that investigates the interrelations between organisms and their environment.

ecosystem - an assemblage of communities that exchange components and are, therefore, dependent on one another; an ecological unit.

ecotone - the transition zone between two different ecosystems.

ecotourism - a branch of the tourist industry that specializes in arranging visits to geographic areas of ecological interest, especially for pleasure or educational purposes.

emergent plants - erect, rooted vegetation that may be temporarily or permanently flooded at the base but do not tolerate prolonged inundation of the entire plant.

emergent wetland - a wetland class characterized by free-standing, herbaceous (nonwoody) vegetation that persists for most of the growing season.

endangered - a classification of species or subspecies in danger of extinction throughout all or a significant part of its range.

epipedon - a diagnostic soil horizon occurring at the soil surface.

estuary - a semi-enclosed coastal body of water that has a measurable salinity gradient from its fresh water drainage to its ocean entrance.

eutrophication (of a body of water) characterized by an abundant accumulation of nutrients that support a dense growth of plant and animal life, the decay of which depletes oxygen in the shallow waters during the growing season.

evapotranspiration - the loss of water from the soil through evaporation and transpiration.

facultative plants - See Appendix C.

facultative upland plants - See Appendix C.

facultative wetland plants - See Appendix C.

fen - a wetland that has a defined outlet and is supported by mineral-rich groundwater that has seeped to the surface.

flooded - a condition in which the soil surface is temporarily covered with water from any source or combination of sources, such as streams overflowing their banks, runoff from adjacent or surrounding slopes, inflow from tidal action.

frequently flooded - a classification of flooding in which flooding is likely to occur often under usual weather conditions (more than 50 percent chance of flooding in any year).

freshwater species - an organism that typically lives in water with a salinity less than 0.5 parts per thousand (ppt).

forested wetland - a wetland class characterized by the presence of woody vegetation more than 20 feet tall.

floodplain - the low-lying land adjacent to a river, stream, or coast that may be submerged during a flood.

genus - the major subdivision of a family or subfamily in the classification of plants and animals, usually consisting of more than one species.

geography - the study of spatial relationships among people, places, and environments. Geographically-informed persons understand and appreciate the interdependent parts of the world in which they live. Although a knowledge of geography is enjoyable in itself, it has practical value by allowing people to apply spatial and environmental perspectives at local and global scales. (*Geography for Life: National Geography Standards* 1994).

gleization - a process affecting soil development, as in waterlogged conditions, where iron is chemically reduced, thus producing mottles within the soil.

gleyed - a soil condition resulting from gleization; manifested by the presence of neutral gray, bluish, or greenish colors through the soil matrix or in mottles (spots or streaks) among other colors.

ground water - that portion of the total precipitation which at any particular time is either passing through or standing in the soil and the underlying strata and is free to move under the influence of gravity.

growing season - the portion of the year when soil temperatures are above biologic zero (5° C), as defined by Soil Taxonomy. The following growing-season months are assumed for each of the soil temperature regimes; however, soil temperature regimes are strictly defined by mean annual temperature and not by growing season:

Type of Growing Season	Northern Hemisphere	Southern Hemisphere
Isohyperthermic	January-December	January-December
Hyperthermic	February-December	August-June
Isothermic	January-December	January-December
Thermic	February-October	August-April
Isomesic	January-December	January-December
Mesic	March-October	September-April
Frigid	May-September	November-March
Cryic	June-August	December-February
Pergelic	July-August	January-February

habitat - the native environment of an animal or plant.

histic epipedon - an 8- to 16-inch soil layer at or near the surface that is saturated for 30 consecutive days or more during the growing season in most years and contains a minimum of 20 percent organic matter when no clay is present or a minimum of 30 percent of organic matter when 60 percent clay or more is present; generally a thin layer of peat or muck in unplowed areas; an organic surface layer too thin to allow classification as a histosol.

histosol - a soil order consisting of organic soil such as peat or muck.

hue - a characteristic of color related to one of the main spectral colors, or various combinations of these principal colors (red, yellow, green, blue, and purple); one of the three variables of color.

hydrologic gradient - the flow of water as influenced by the degree and route of declination.

hydrology - the science that investigates the properties, distribution, and circulation of water.

intertidal - the area of a shoreline or tidal wetland between mean high and mean low tides.

introduced species - not native; released locally either accidentally or by intentional human intervention.

inundation - a condition in which water temporarily or permanently covers a land surface.

latitude - the angular distance north or south from the equator of a point on the earth's surface, measured on the meridian of the point.

levee, artificial - a flood-prevention embankment constructed along the natural bank of a river or stream.

levee, natural - an alluvial deposit built up along, and sloping away from, either side of the floodplain of a river or stream.

long duration flooding - a classification of flooding where water inundates an area for a single period ranging from seven days to one month.

longitude - the angular distance east or west on the earth's surface, measured by the angle contained between the meridian of a particular place and some prime meridian, as that of Greenwich, England, and expressed in degrees.

marsh - an emergent wetland with a regular inlet and outlet of water.

meridian - any imaginary great circle of the earth passing through the poles and any given point on the earth's surface.

metabolism - the sum of the physical and chemical processes by which an organism produces, maintains and destroys the living matter within its cells (protoplasm), and by which energy is made available.

mineral soil - any soil consisting primarily of mineral (sand, silt, and clay) material; as opposed to organic soil.

mire - a section of wet, swampy ground; bog; marsh.

moss-lichen wetland - a wetland class characterized by the growth of peat mosses and lichens; usually called a bog; most abundant in the northern latitudes.

mottled - spotted or blotched coloration interspersed among a dominant color.

muck - an organic soil in which the organic matter is well decomposed.

mud flat - a frequently inundated area, generally parallel to the shore, but separated from the shore by water, composed of unconsolidated sediments, usually silt and clay (mud) or sand, and generally lacking vegetation.

nitrogen fixation - the process of combining atmospheric nitrogen with other elements through bacterial action within the soil, thus generating various nitrogen compounds in forms usable in plant metabolism.

non-hydric soil - a soil that has developed under predominantly aerobic soil conditions.

non-point source (contamination) - waterborne or airborne pollutants originating from multiple locations, such as from chemically-treated agricultural areas.

non-tidal - not influenced by tides.

non-wetland - not a wetland; an area that is either a deepwater habitat or an upland ecosystem.

nutrient - a compound or element required by organisms for growth and reproduction.

obligate upland plant - See Appendix C.

obligate wetland plant - See Appendix C.

organic - any compound containing the element carbon.

organic soil - see histosol; not a mineral soil.

over enrichment - the excessive loading of nutrients (particularly nitrogen and phosphorus) in a body of water that results in algal blooms and associated turbid (cloudy) and anoxic (abnormally low oxygen) conditions; See eutrophication.

oxidation-reduction process - a complex of biochemical reactions in soil that influences the electron configuration (valence state) of chemical elements or ions within the soil.

oxidized root zones - the immediate area surrounding plant roots where a subtle, yet distinct rust-like discoloration occurs as a growth response to hydric soil conditions.

parent material - the unconsolidated mineral or organic matter from which soils are developed.

parts per thousand (ppt) - used in describing the concentration of salt in brackish and marine waters; refers to the number of parts (grams) of salt per thousand parts (grams) of water.

peat - an organic soil consisting largely of undecomposed, or only slightly decomposed, organic matter accumulated under conditions of excessive moisture. Highly organic varieties, when dried, are combustible and may be used as a fuel.

percolation, soil water - the downward movement of excess water through the soil.

permanently flooded - a condition where water covers the land surface throughout the year in all years.

permeability, soil - the ease with which gases, liquids, and plant roots penetrate or pass through soil.

pH (power of Hydrogen) - the symbol for the logarithm of the reciprocal of hydrogen ion concentration in gram atoms per liter. For example, a pH of 5 indicates a concentration of 0.00001 or 10^{-5} gram atoms of hydrogen ions in one liter of solution. The pH scale ranges in value from 1: 14: 7 indicates ion neutrality, lesser numbers indicate acidic conditions, and greater numbers indicate alkaline conditions. See acid and alkaline.

pioneer plant - herbaceous annual and seedling perennial plants that colonize by natural means on bare areas as a first stage in secondary succession.

point-source (contamination) - waterborne or airborne pollutants originating from a specific location, such as from a ruptured storage tank.

ponded - a condition in which water stands in a closed depression, and therefore, the only natural means of exit for the water is through percolation, evaporation, or transpiration.

poorly drained soil - a condition in which water is removed from the soil so slowly that the soil is saturated periodically during the growing season or remains wet for long periods.

pore space, soil - space in the soil not occupied by solid particles.

porosity, soil - the total volume of pore space, usually expressed as a percentage of the total soil volume.

prime meridian - a meridian from which longitude east and west is reckoned, usually that of Greenwich, England (0° Longitude).

rare - a classification of species or subspecies that is uncommon within a certain region.

reef wetland - a wetland class characterized by ridge-like or mound-like structures formed by the colonization and growth of sedentary invertebrates (corals).

retention time - the duration over which a volume of water circulates completely through a given basin.

rock bottom wetland - a wetland class characterized by an areal cover of stones, boulders, or bedrock 75 percent or greater and vegetative cover of less than 30 percent, and relatively frequent and consistent inundation.

rocky shore wetland - a wetland class characterized by the same areal coverage requirements as the rock bottom class, but differing in that the water regime is less frequent and consistent.

runoff - precipitation that drains from the surface and into surface waterways.

saline - pertaining to seawater (over 30 parts per thousand [ppt] salinity); marine.

salinity - the measurement of dissolved salts in water, usually expressed in parts per thousand (ppt).

sand bar - an elongated sandy landform generated by waves and currents, usually running parallel to the shore, with water on two sides.

saturated - a condition in which all voids (pore spaces) are filled with water.

shrub-scrub wetland - a wetland class characterized by woody vegetation less than 20 feet tall.

soil - (1) the unconsolidated mineral material on the immediate surface of the earth that serves as a natural medium for the growth of land plants; (2) the unconsolidated mineral material on the immediate surface of the earth that has been subjected to and influenced by genetic and environmental factors of parent material, climate (including moisture and temperature), macro- and microorganisms, and topography, all acting over a period of time and producing a product: soil. A soil differs from the material from which it is derived in many physical, chemical, biological, and morphological properties.

soil horizon - a layer of soil or soil material approximately parallel to the land surface and differing from adjacent genetically related layers in physical, chemical, and biological properties or characteristics such as color, structure, texture, consistence, organic matter, and pH.

soil phase - a subdivision of a soil series or other unit of classification having characteristics that affect the use and management of the soil but do not vary sufficiently to differentiate it as a separate series. A variation in a property or characteristic of soil such as texture, slope, degree of erosion, or content of stones.

soil profile - a vertical section of the soil through all its horizons and extending into the parent material.

soil science (pedology) - the science concerned with the study of soils.

soil series - the basic unit of soil taxonomy and consisting of soils that are essentially alike in all major profile characteristics, except not necessarily in the texture of the surface layer.

somewhat poorly-drained soil - a condition in which water is removed slowly enough that the soil is wet for significant periods during the growing season.

species - the major subdivision of a genus or subgenus, regarded as the most basic biological classification of plant and animal types that resemble one another and are able to breed among themselves, but unable to breed with members of another species.

strata (geologic) - layers of material that are roughly parallel and placed one upon another.

strata (vegetative) - layers of vegetation used to determine dominant species in a plant community (i.e., trees, saplings, shrubs, woody vines, and herbaceous vegetation).

stream bed wetland - a wetland class characterized by the presence of channels that are flooded regularly, irregularly, seasonally, or intermittently.

submerged aquatic vegetation (SAV) - underwater aquatic plants.

subspecies - a subdivision of a species.

substrate - the immediate underlying geologic material other than true soils; nonsoil. Sometimes used in reference to all such material, including soil.

subtidal - the zone of the shoreline and water basin below low tide, always covered by water.

supratidal - the zone of the shoreline above high tide.

surface water - a semi-permanent or permanent body of water that is free-standing or flowing on the earth's surface, excluding runoff.

swamp - a shrub-scrub or forested wetland that has a regular inlet and outlet of water.

temporarily flooded - a condition where water is present for brief periods during the growing season, but the water table usually lies well below the soil surface for most of the season.

threatened species - a classification of species or subspecies that is likely to become endangered in the foreseeable future throughout all or a significant part of its range.

tidal - a situation in which the water level periodically fluctuates because of the action of lunar (moon) and solar (sun) forces upon the rotating earth.

topography - the configuration of a surface, including its relief and the position of its natural and artificial features

torf - German word for peat; see peat.

transect - a line on the ground along which sampling points are established for collecting vegetation data and in many cases, soil and hydrologic data as well.

transpiration - the process by which plants release water into the gaseous environment (atmosphere).

turbidity - cloudiness in water derived from algae, suspended silt, or other impurities.

unconsolidated bottom wetland - a wetland class characterized by a relative absence of stable surfaces upon which vegetation may take root.

unconsolidated shore wetland - a wetland class characterized by a relative absence of stable surfaces upon which vegetation may take root, except for pioneering plants.

upland - any area that does not qualify as a wetland because the associated hydrologic regime is not sufficiently wet to permit development of vegetation, soils, or hydrologic characteristics associated with wetlands. Such areas occurring in floodplains are more appropriately termed nonwetlands.

value - the relative lightness or intensity of color; one of the three variables of color.

very long duration flooding - water inundation for a single period in excess of one month.

very poorly drained - a condition in which water is removed from the soil so slowly that free-standing water remains at or on the surface during most of the growing season.

water mark - a line on vegetation or other upright objects that represents the maximum height reached in an inundation event (flood).

water table - that level in saturated soil where the hydraulic pressure is zero; the uppermost zone of saturation beginning downward through the soil.

wetland - See "Definitions of Wetlands "

wooded swamp - a wetland dominated by trees; a forested wetland

B. Common Wetland Indicator Vegetation

The following list includes species of grasses, sedges, rushes, herbaceous, shrubs and trees common to freshwater wetlands of the northeastern United States (Tiner 1987). The list is far from inclusive. Excluded from the list are many vegetative species common to marine and freshwater wetlands where long-duration and permanent flooding occurs. In such places, wetland hydrologic conditions are usually so apparent that hydrology takes precedence over plant species (hydrophyte) identification in wetland delineation projects. Indicator Status definitions are found at Appendix C.

Species	Common Name	Indicator Status
Acer negundo	Box Elder	Facultative
Acer rubrum	Red Maple	Facultative
Acer saccharinum	Silver Maple	Facultative Wet
Acorus calamus	Sweet Flag	Obligate
Alnus rugosa	Speckled Alder	Facultative Wet
Asclepias incarnata	Swamp Milkweed	Obligate
Betula alleghaniensis	Yellow Birch	Facultative
Betula lenta	Sweet Birch	Facultative Upland
Betula nigra	River Birch	Facultative Wet
Betula papyrifera	Paper Birch	Facultative Upland
Betula populifolia	Gray Birch	Facultative
Bidens cemua	Nodding Beggarticks	Facultative Wet
Bidens connata	Swamp Beggarticks	Facultative Wet
Butomus umbellatus	Flowering-rush	Obligate
Calamagrostis canadensis	Bluejoint	Facultative Wet
Calla palustris	Water Arum	Obligate
Caltha palustris	Marsh Marigold	Obligate
Carex intumescens	Bladder Sedge	Obligate
Carpinus caroliniana	American Hornbeam	Facultative
Cephalanthus occidentali	Buttonbush	Obligate
Chamaedaphne calyculata	Leatherleaf	Obligate
Cicuta maculata	Water Hemlock	Obligate
Cladium mariscoides	Twig Rush	Obligate
Coptis trifolia	Goldthread	Facultative Wet
Comus amomum	Silky Dogwood	Facultative Wet
Cornus stolonifera	Red Osier Dogwood	Facultative Wet
Cyperus strigosus	Umbrella Sedge	Facultative Wet
Decodon verticillatus	Swamp Loosestrife	Obligate
Dulichiuma rundinaceum	Three-way Sedge	Obligate
Echinochloa walteri	Walter Millet	Facultative Wet
Eleocharis rostellata	Beaked Spike-rush	Obligate
Equisetum fluviatile	Water Horsetail	Obligate
Erythronium umbilicatum	Trout Lily	Facultative
Eupatoriadelphus maculatus	Spotted Joe-pyeweed	Facultative Wet
Eupatorium perfoliatum	Boneset	Facultative Wet

Species	Common Name	Indicator Status
Fraxinus americana	White Ash	Facultative W
Fraxinus nigra	Black Ash	Facultative Wet
Fraxinus pennsylvanica	Green Ash	Facultative Wet
Hamamelis virginiana	Witch Hazel	Facultative
Helenium autunmale	Sneezeweed	Facultative Wet
Hydrophyllum virginianum	Virginia Waterleaf	Facultative Wet
Hypericum densiflorum	Bushy St.John's Wort	Facultative
Ilex verticillata	Common Winterberry	Facultative Wet
Impatiens capensis	Spotted Touch-me-not	Facultative Wet
Impatiens pallida	Pale Touch-me-not	Facultative Wet
Iris versicolor	Blue Flag	Obligate
Iris pseudacorus	Yellow Flag	Obligate
Juncus effusus	Soft Rush	Facultative Wet
Juncus canadensis	Canada Rush	Obligate
Justicia americana	Water-willow	Obligate
Larix laricina	Tamarack	Facultative Wet
Leersia oryzoides	Rice Cutgrass	Obligate
Lindera benzoin	Spicebush	Facultative Wet
Liquidambar styraciflua	Sweet Gum	Facultative
Lobelia cardinalis	Cardinal Flower	Facultative Wet
Lobelia siphilitica	Great Lobelia	Facultative Wet
Lycopus americanus	Water Horehound	Obligate
Lythrum salicaria	Purple Loosetrife	Facultative Wet
Myrica pennsylvanica	Northern Bayberry	Facultative
Nyssa sylvatica	Black Gum	Facultative
Onoclea sensibilis	Sensitive Fern	Facultative Wet
Osmunda cinnamomea	Cinnamon Fern	Facultative Wet
Osmunda claytoniana	Interrupted Fern	Facultative
Osmunda regalis	Royal Fern	Obligate
Phalaris arundinacea	Reed Canary Grass	Obligate
Phragmites australis	Common Reed	Facultative Wet
Picea mariana	Black Spruce	Facultative Wet
Platanus occidentalis	Sycamore	Facultative Wet
Polygonum scandens	Hedge Cornbind	Facultative
Pontederia cordata	Pickerelweed	Obligate
Populus deltoides	Eastern Cottonwood	Facultative
Quercus bicolor	Swamp White Oak	Facultative Wet
Quercus palustris	Pin Oak	Facultative Wet
Rhododendron maxumum	Rosebay Rhododendron	Facultative
Rosa multiflora	Multiflora Rose	Facultative Upland
Rosa palustris	Swamp Rose	Obligate
Rumex verticillatus	Swamp Dock	Obligate

Species	Common Name	Indicator Status
Sagittiaria latifolia	Broadleaf Arrowhead	Obligate
Salix sericea	Silky Willow	Obligate
Sambucus canadensis	Common Elderberry	Facultative Wet
Saururus cernuus	Lizard's Tail	Obligate
Scirpus atrovirens	Green Bulrush	Obligate
Scutellaria lateriflora	Mad-dog Skullcap	Facultative Wet
Spiraea tomentosa	Steeplebush	Facultative Wet
Symplocarpus foetidus	Common Skunk Cabbage	Obligate
Thelypteris noveboracensis	New York Fern	Facultative
Thelypteris simulata	Massachusetts Fern	Facultative Wet
Thelypteris thelypteroides	Marsh Fern	Facultative Wet
Toxicodendron vernix	Poison Sumac	Obligate
Tsuga canadensis	Eastern Hemlock	Facultative Upland
Typha latifolia	Broad-leaved Cattail	Obligate
Ulmus americana	American Elm	Facultative Wet
Ulmus rubra	Slippery Elm	Facultative
Vaccinium corymbosum	Highbush Blueberry	Facultative Wet
Vaccinium macrocarpon	American Cranberry	Obligate
Verbena hastata	Blue Vervain	Facultative Wet
Vernonia noveboracensis	New York Ironweed	Facultative Wet
Viburnum dentatum	Southern Arrowwood	Facultative
Viburnum recognitum	Northern Arrowwood	Facultative Wet

C. How to Use The Munsell Soil Color Charts

The Munsell Soil Color Charts provide a systematic method for determining the hue, value, and chroma of a soil. Hue refers to the spectral color; value refers to the degree of lightness or darkness of the color; and chroma indicates the strength or purity of the dominant color of the soil. Though all three variables provide vital information about a given soil, chroma is the most essential in determining whether a soil is hydric. A chromatic rating of two or less indicates that a soil is hydric. If a dominating spectral color is absent, the chroma is zero and the color may range from absolute black through the grays to absolute white depending on the value (degree of lightness or darkness). Since low chromatic indices (less than 2) are used in hydric soil determination, a chroma of zero or absolute black is possible; however, the Munsell Soil Color Charts do not provide chroma indices of zero for any hue.

The Munsell Soil Color Charts contain color chips of similar hue per each chart, denoted by a number-letter code. A letter (R for red, YR for yellow-red, and Y for yellow) is preceded by a number (0: 10). For example, the designation 5YR means that the soil is in the middle of the yellow-red range of hues. Once the correct chart (hue) is located, the user of the Munsell Soil Color Chart continues comparing the soil sample with the color chips of that chart until a match is found. The individual charts contain holes under each color chip so that the soil sample may be held underneath, and flush with, the chip for close comparison. For the chip which best matches the soil sample, the value is read from the y-axis and the chroma is read from the x-axis on that chart. One example of a hydric soil, properly annotated is: 5YR 4/1. (This indicates a mid-range (5) yellow-to-red (YR) soil with a value of 4 and chroma of 1. Remember, the chroma rating determines whether the soil is hydric. A soil rated as 5YR 4/3 would not qualify as hydric because the chroma is not less than 2.

Because the coloration of a given soil varies with moisture content, the Munsell Soil Color Charts are designed for assessing moist soil samples. If a soil sample is dry, it must be moistened by artificial means before classifying its hue, value, and chroma.

D. Technical Criteria: Hydrophytic Vegetation, Hydric Soils, and Hydrology

Hydrophytic Vegetation Groupings and Wetland Hydrophyte Criteria

The *National List of Plant Species That Occur in Wetlands* separates plants into four groups, commonly known as the "wetland indicator status," based on the species' frequency of natural occurrence in a wetland environment:

1. Obligate wetland species (OBL) occur almost exclusively in wetlands (estimated probability 99 percent).
2. Facultative wetland species (FACW) usually occur in wetlands (estimated probability 67-99 percent), but occasionally occur in nonwetland areas.
3. Facultative species (FAC) are equally likely to occur in wetlands or nonwetlands (estimated probability 34-66 percent).
4. Facultative upland species (FACU) usually occur in nonwetland areas (estimated probability 67-99 percent), but occasionally occur in wetlands.

A fifth grouping of species, not found on the national list, includes those species that occur in wetlands with an estimated probability of less than 1 percent. These obligate upland species (UPL) are found only on regional wetland plant lists and are listed only if a species' frequency of occurrence is atypically high within that region as compared to the national frequency of occurrence.

In general, the hydrophytic vegetation criterion is met if more than 50 percent of the dominant species from all strata (e.g., tree, shrub, and herb) are OBL, FACW, or FAC species. Precise determination is based on detailed quantification that is beyond the scope of our identification and delineation procedure. Therefore, consider an area to be wetland if OBL species (alone) dominate that area. The other mandatory criteria, hydric soils and wetland hydrology, are presumed to exist in this circumstance. Soil sampling is NOT required.

Hydric Soils Criteria

In general, a mineral soil is hydric if the chromatic index is 2 or less, as assessed with the Munsell Soil Color Chart.

Specifically, an area has hydric soils if it meets the National Technical Committee for Hydric Soils (NTCHS) criteria for hydric soils. All soils that meet the NTCHS criteria are listed on the National Hydric Soils List. State and county hydric soils lists contain hydric soils pertinent to their respective regions.

Wetland Hydrology Criteria

In general, an area has wetland hydrology when it is:

1. saturated to the surface for any period during an average rainfall year (Specific saturation criteria vary for mineral soils and organic soils. These specifics are beyond the scope of our

identification and delineation procedure.), or

2. inundated at some time if ponded or frequently flooded with surface water for one week or more during the growing season.

Wetland hydrology is the least technical and often the most difficult criterion to assess because of annual, seasonal, and daily fluctuations in water levels. Consider these periodic fluctuations when evaluating field indicators such as buttressed tree trunks, multiple tree trunks, drift lines (e.g., accumulated leaf litter), and scoured (washed out) surface areas.

E: Data Form[1] for Delineating Wetlands

Intermediate-level Onsite Determination Method or Comprehensive Onsite Determination Method Summary Sheet

Field Investigator(s): ________ Date: ________

Project/Site: ________ State: ________ County: ________

Applicant/Owner: ________

Intermediate-level Onsite Determination Method: ________

Comprehensive Onsite Determination Method: ________

Transect #: ________ Plot#: ________ Vegetation Unit #/Name: ________

Note: If a more detailed site description is necessary, use the back of data form or a field notebook

Do normal environmental conditions exist at the plant community?

Yes: ________ No: ________ (If no, explain on back)

Have the vegetation, soils, or hydrology been significantly disturbed?

Yes: ________ No: ________ (If yes, explain on back)

Dominant Plant Species	Indicator Status	Stratum	Dominant Plant Species	Indicator Status	Stratum
1.			14.		
2.			15.		
3.			16.		
4.			17.		
5.			18.		
6.			19.		
7.			20.		
8.			21.		
9.			22.		
10.			23.		
11.			24.		
12			25.		
13			26.		

Percent of dominant species that are OBL, FACW, or FAC ________

Is the hydrophytic vegetation criterion met? Yes: ________ No: ________

Is the hydric soil criterion met? Yes: ________ No: ________

Is the wetland hydrology criterion met? Yes: ________ No: ________

Is the vegetation unit or plot wetland? Yes: ________ No: ________

Rationale for jurisdictional decision: ________

[1] This data form can be used for the Intermediate-level Onsite Determination Method or the Comprehensive Onsite Determination Method. Indicate the method you will use.

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SELECTED RESOURCE LIST

This publication hopes to provide a moderately comprehensive introduction to wetlands. During our research, many hundreds of current wetland and wetland-related articles were available in more than 125 different professional journals and magazines. Innumerable government publications and dozens of professional textbooks are also available. In short, addressing all of the complex and diverse facets of wetlands is beyond the scope of this or any other single publication of practical use.

The following resource list should assist those interested in further wetland study. The list provides a sampling of the many and varying perspectives found within wetland literature. Included are articles with technical scientific, political, and geographic orientations. Because of the critical and controversial content of some wetland literature, it is necessary to mention that our list neither endorses the following material nor criticizes adversely any excluded material.

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In addition to the information in Figure 17: Primary Sources of Helpful Materials, "Wetland Identification and Delineation," the following points of contact are listed.

Governmental Agencies

Environmental Protection Agency (EPA)
401 M Street, SW
Washington, DC 20460

Office of Wetlands Protection
Regulatory Activities Division
(202) 382-5048

Municipal Pollution Control
Michael J. Quigley, Director
(202) 382-5850

Water Regulations and Standards
Martha G. Pronthro, Director
(202) 382-5400

Federal Emergency Management Agency
Federal Center Plaza
500 C Street, SW
Washington, DC 20472
(202) 646-4600

National Marine Fisheries Service,
Northeast Region
1 Blackburn Drive
Gloucester, MA 01930
(508) 281-9300

National Park Service
Recreation Resources Assistance Division
P.O. Box 37127
Washington, DC 20013
(202) 343-2780

U.S. Geological Survey
Earth Science Information Survey
507 National Center
Reston, VA 22092
(800) USA-MAPS

Nongovernmental Agencies

Association of State Wetland Managers
P.O. Box 2463
Berne, NY 12023
(518) 872-1804

Environmental Law Institute
1616 P Street, NW
Washington, DC 20036
(202) 328-5150

Izaak Walton League of America
1401 Wilson Blvd., Level B
Arlington, VA 22209
(703) 528-1818

Land Trust Exchange
1017 Duke Street
Alexandria, VA 22314
(703) 683-7778

National Wildlife Federation
1400 16th Street, NW
Washington, DC 20036
(202) 797-0250

Society of Wetland Scientists
P.O. Box 296
Wilmington, NC 28402

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